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the significance

of chemical rays of light for medicine and biology.

Three treatises.

by

Prof. Dr. Niels R. Finsen in Copenhagen. With 6 illustrations and 6 plates. Gr. 8.

1899. Price M. 2.50.

On the application of concentrated

chemical light rays in medicine

by

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Printed by August Pries in Leipzig.

COMMUNICATIONS FROM

FINSENS

MEDICINSKE LYSINSTITUT

(FINSEN'S MEDICAL LIGHT INSTITUTE) IN COPENHAGEN

I

EDITED BY PROF. DR. NIELS R. FINSEN

THE GERMAN EDITION EDITED BY DR. VALDEMAR BIE, LABORATORY ASSISTANT

AT

THE

INSTITUTE

LEIPZIG

PUBLISHED BY F. C. W. VOGEL 1900

Turn of the Century Electrotherapy Museum Edition
Compiled by Jeff Behary

COMMUNICATIONS FROM

FINSENS

MEDICINSKE LYSINSTITUT (FINSEN'S MEDICAL LIGHT INSTITUTE) IN COPENHAGEN

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Foreword to the German edition.

This book is a translation of "Meddelelser fra Finsens medicinske Lysinstitut" [1], published in Danish in 1899. Various changes have been made, particularly abbreviations; one work (Some Investigations into the Relationship between Erysipelas and Lupus Vulgaris by V. Eilschou Holm) has been omitted because it lies in the purely dermatological field and consequently has nothing to do with photobiology or phototherapy

In order for the German edition to appear in the most correct language possible, it was necessary for a German physician to correct the translation. In agreement with Professor Finsen, I turned to Dr. Sarason (formerly in Hamburg, now in Berlin), who was the first German physician to practice Professor Finsen's treatment with concentrated chemical light rays. He read through and corrected the manuscript of articles V, VI, and VIII with great benevolence. Since Dr. Sarason in Berlin was unable to deal with Finsen's treatment and was also prevented from continuing the corrections, a

1) Dr. Sarason has, among other things, published his experiences with this method in a lecture (Sarason: On Finsen's Lupus Treatment. Lecture, held at the 20th Meeting of the Balneological Society in Berlin in March 1899. Deutsche Medizinal-Zeitung 1899, Nos. 53-55).

another Berlin doctor, Dr. Theodor Student, who Acquired Sarason's apparatus and set up a Finsen department in Berlin, the correction. The same reviewed Articles Nos. I, II, III and IV. I have compared the translation

with the Danish edition and am responsible for ensuring that the opinion of the same is accurately reflected.

Copenhagen, May 1900.

Valdemar Bie.

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Foreword to the Danish edition.

For many reasons, it is preferable to publish the communications and scientific works of the Light Institute in a collected form, rather than scattered across various journals as has been the case up to now. Therefore, this issue will begin a series of "Communications from Finsen's Medical Light Institute."

What these communications will usually be like is best understood from the task, or rather from the tasks, that the Institute has set itself. The first and most essential task is the investigation of light and its effects, for only in this way can a healthy and solid foundation be established for the second task of the Light Institute, namely: the application of light in medicine. The first task requires investigations of a physical, chemical, and biological nature; the second task requires practical medical investigations, experiments on various diseases. Naturally, works will also appear that lie in another field, but which are nevertheless somehow connected with the work of the Institute. On the other hand, works that do not originate from the Institute itself, but which touch on our specific field, can also be included in these communications. Furthermore, it is intended to include critical

To provide analyses and surveys of the entire literature on light.

It is difficult to make firm decisions regarding the publication of these reports, both in terms of time and scope. For the time being, the present material will be published gradually.

Copenhagen, January 1899.

Niels R. Finsen.

I

Finsens medicinske Lysinstitut.

(Finsen's Medical Light Institute).

In April 1896, a group of gentlemen gathered here in Copenhagen, some of them university professors from the medical faculty and outstanding physicians, and some of men of great influence, whose names are listed below, to create the conditions for a thorough study of the effects of light, with special consideration of their significance for medicine. The reason for this was my investigations into the physiological effects of light, and particularly my demonstration of the powerful influence of light on the course of smallpox, as well as a case of lupus vulgaris that I had cured with concentrated chemical light rays.

It has now been decided to establish a public, independent institution called "Finsen's Medical Light Institute," whose task, according to Section 1 of the statute, is "to conduct and promote investigations into the effects of light on living organisms, primarily for the purpose of applying light rays in the service of practical medicine."

The administration of the Light Institute consists of a senior management and an executive committee. The senior management forms

14 gentlemen, namely the founders of the institute, namely Mayor Borup, President; University Professor of Pathological Anatomy Dr. Carl Lange, Vice-President; Director of the Municipal Hospitals, Justice Counselor Gred-Sted, Secretary; Factory Owner, Candidate Polytechnician Wilh. Joergensen, Treasurer; University Professor of Anatomy Dr. Chievitz; Senior Physician at the Öresund Hospital, Professor Feil-Berg; Factory Owner, Candidate Polytechnician Hagemann; Senior Physician at the Municipal Hospital, Professor Dr. Haslund; Manufacturer, Candidate Polytechnician Juhler; Engineer Niels Mogensen; University Professor of General Pathology Dr. C. J. Salomonsen; Senator WASSARD, Senior Court Advocate, and WINDFELD-HANSEN, Director of the Municipal Lighting System. The Executive Committee consists of the factory owner HAGE-MANN, — President, Justice Counselor GREDSTED, Professor HASLUND, factory owner JÖRGENSEN, Engineer MOGENSEN, and Professor SALOMONSEN. The institute is headed by the undersigned in scientific and medical matters.

Thanks to great kindness from various quarters, it was possible to establish a home for the institute. The Copenhagen municipality donated a building site in the immediate vicinity of the "municipal hospital" and further offered to provisionally provide the institute with electricity and all other resources from the hospital. The Carlsberg Fund approved a sum of 2,500 crowns for the establishment of the laboratory, and the two aforementioned gentlemen, G. A. Hagemann and Wilh. Jorgensen, provisionally advanced the funds for the construction of a building, which was immediately begun, and scientific work began as early as August of the same year. At the end of the year, the aforementioned gentlemen donated the entire construction sum to the institute. However, after just one year, the building as constructed proved to be too small, and therefore, in 1897,

With the help of a state subsidy of 20,000 crowns, a new and significantly larger building was erected, like the first, made of wood and glass, in the style of a studio. While the first building originally contained both a laboratory and an experimental clinic, it was now entirely converted into a laboratory, and the new building housed the clinic exclusively. In addition to these buildings, sunbathing areas, animal stables, etc., were also built.

These buildings had long been insufficient, and the work of the institute suffered greatly from this deficiency; however, conditions will soon improve, as the institute acquired a large property that will be prepared in a short time to accommodate a laboratory, while a clinic must be specially built. Furthermore, it is possible that the institute will receive substantial state aid this year, as a sum of 240,000 crowns will be given to the Lighting Institute as an interest-free loan, in accordance with the proposal in this year's finance law

At the same time as explaining the origins and external conditions of the institute, I will provide some information about the institute's internal facilities and work. As mentioned above, the Light Institute consists of two departments: the laboratory and the clinical department, which are naturally closely connected and mutually support each other.

The clinical department deserves special mention, and some figures from it best illustrate the extraordinarily large growth of the Light Institute over the past 2.5 years. During this period, a total of 333 patients have been treated with concentrated chemical rays; of these, 244 were treated for lupus vulgaris, 89 for other skin diseases as an experiment (the indication for this treatment is superficial, local, bacterial skin infections).

suffer). These patients are distributed over the past period as follows: in 1896, 15 patients, in 1897, 97 patients, in 1898, 221 patients. In addition to these, approximately 30 patients were treated experimentally with photochemical baths

The institute's staff has increased in the same proportion. Now, at the end of 1898, it consists of 7 physicians, 1 physicist, 1 electrician, and 33 nurses, as well as subordinate personnel. The physicians currently employed at the laboratory are: Messrs. S. Bang, Vald. Bie, and V. Siim; at the clinic: H. Forchhammer, Axel Larsen, and Eilschou Holm. Dr. Bang is head of the laboratory, Dr. Forchhammer is head of the clinic. Our physical collaborator is Mr. Candidate Mag. Absalon Larsen. Among our staff, I can also add Dr. Holger Mygind, who has kindly offered the Light Institute his assistance with the numerous laryngological ailments presented by patients with lupus vulgaris

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The following communications have emerged from the Light Institute to date, partly in the form of treatises, partly as lectures or demonstrations; I list them in chronological order:

Niels R. Finsen: Om Anvendelse of koncentrerede, kemiske Lys-straaler i Medicinen. (On the application of concentrated chemical light rays in medicine). Copenhagen, December 1896. (Gyldendals Verlag).

S. Bang: Om Behandling af Lupus vulgaris med koncentreret Lys. Foredrag med Demonstration af Patienter ved det alm. danske Lägemöde i Fredericia. (On the treatment of lupus vulgaris with concentrated light. Lecture with demonstrations

of patients at the general meeting of Danish physicians in Fredericia. August 1897).

Niels R. Finsen: Treatment of lupus vulgaire by concentrated chemical rays. Medical week, December 22, 1897.

Valdemar Bie: On the effect of the various divisions of the spectrum on bacteria. Presented by Professor Salomonsen at the Society of Sciences on April 15, 1898. Oversigt over det kgl. danske Videnskabernes Selskabs Forhandlinger 1898, No. 2, p. 29. (Overview of the proceedings of the Royal Danish Society of Sciences 1898, No. 2, p. 29).

S. BANG: Finsen's Light Therapy. Monthly Journal of Practical Dermatology, Vol. XXVII, 1898.

S. BANG: The Results of Lupus Treatment with Concentrated Chemical Rays. (The Results of Lupus Treatment with Concentrated Chemical Rays). Lecture with demonstration at the 6th Scandinavian Congress of Natural Scientists in Stockholm, July 1898.

VALDEMAR BIE: On the Effects of Light on Microorganisms. (On the Effects of Light on Microorganisms). Lecture at the 6th Scandinavian Congress of Natural Scientists in Stockholm, July 1898

S. BANG: Treatment of lupus by concentrated luminous rays, after Professor Finsen's method. Lecture at the 4th Tuberculosis Congress in Paris. August 1898.

NIELS R. FINSEN: Report for Finsen's Medical Lys Institute. (August 1896 to December 1897). (Annual report) September 1898.

H. FORCHHAMMER: Results of lupus treatment at Finsen's Medical Lys Institute. (The results of lupus treatment at Finsen's Medical Lys Institute). Lecture including demonstration of (approx. 50) patients at the Medical Society in Copenhagen, November 15, 1898

Niels R. Finsen: Phototherapy.
Contents: I. Chemical rays and light. II. Light as an excitation agent. III. Treatment of lupus vulgaire with concentrated chemical rays (Carré et Naud), Paris 1899.

Niels R. Finsen.

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*) The following was published from January 1899 to May 1900:

Niels R. Finsen: On the application of concentrated chemical light rays in medicine. Leipzig 1899. (Vogels Verlag.)

Niels R. Finsen: On the significance of chemical rays of light for medicine and biology. Leipzig 1899. (Vogels Verlag.) (German edition of "La Photothérapie")

NIELS R. FINSEN: Meddelelser fra Finsens medicinske Lysinstitut II (Reports from Finsen's medicinske Lysinstitut II). Copenhagen. December 1899. (Gyldendals Verlag.) Contents:
I. SOFUS BANG: Om Lysets Virkninger paa Mikrober. I. Variationer i Modstandsevnen hos B. prodigiosus efter Kulturens Alder og Temperatur (On the effects of light on microbes. I. Variations in resistance in B. prodigiosus according to the age and temperature of the culture.)
II. ABSALON LARSEN: Actinoskopet (The Actinoscope.)
III. ABSALON LARSEN: Et Fotometer (A Photometer.)
VI. ABSALON LARSEN: Om Buelysets Variation med Ström og Spænding. (On the variation of the arc light with current and voltage.)

SOFUS BANG: Om Lysets Virkninger paa Mikrober. (On the Effects of Light on Microbes). Lecture at the Biological Society in Copenhagen.

VALDEMAR BIE: Remarks on Finsen's Phototherapy. The British Medical Journal, September 30, 1899.

VALDEMAR BIE: Finsen's Phototherapy. The Philadelphia Medical Journal, October 7, 1899.

VALDEMAR BIE: Professor N. R. Finsen's Light Therapy. Journal for Electrotherapy and Medical Electrotechnology, November 1899.

VALDEMAR BIE: Finsen's Phototherapy. Therapeutic Monthly, January 1900.

VALDEMAR BIE: Finsen's Phototherapy. The Medical Week, 1900, No. 3, January 29

II.

New Investigations on the Effects of Light on the Skin

by

Niels R. Finsen.

In several of my earlier treatises 1) I have dealt with the effects of light on the skin, partly mentioning the various works in this field (Charcot, Widmark, Hammer, Unna, Maklakoff, Defontaine, Wedding) and partly reporting my own investigations. Therefore, I will not go into a general description of the effects of light on the skin here again, but will limit myself to reporting and discussing in more detail some experiments, through which I have partly confirmed earlier investigations and partly made new observations.

In December 1896, at the Light Institute, we began working with a very powerful electric arc lamp (80 amps).

1) FINSEN: Om Lysets Indvirkninger paa Huden. Hospitalstidende. July 5, 1893
— On the chemical effects of radiation on dangerous organisms. Hospital Week. November 1, 1893.
— Chemical rays and the varicose veins. Medical Week. June 30, 1894.

are being investigated. Their luminous intensity may be estimated at a little over 40,000 standard candles; for comparison, the electric arc lamps used to illuminate public spaces in large cities usually have a luminous intensity of 2,000 to 4,000 standard candles

At first, when we conducted experiments with the light from this lamp, and before we had learned to be careful, it severely attacked our skin and our eyes, and we all felt the intensity of the light one after the other. Especially on the day after the experiments, the skin on the face and neck was burning warm, red, and sensitive to the touch. The conjunctivae were very strongly injected; one had the sensation of grains of sand in the eyes and was afraid of light. Fortunately, inflammation of the inner parts of the eye did not occur, since we always wear completely black-tinted glasses when we have to look at the arc of light.

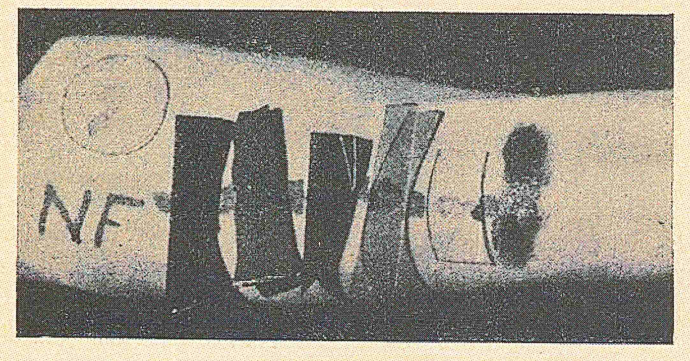
In order to investigate various circumstances concerning this photoinflammation of the skin, and especially to learn what proportion the different types of rays contributed to this inflammation, I carried out the following experiments on my left forearm.

The fact that I made my own arm the subject of my experiment was mainly for the practical reason that observation could thus be undertaken at any time

For the sake of accuracy, I must first state that the skin on my arm was completely white and unpigmented, and that the arm was covered with clothing every day.

Since I was also using the flexor side of the forearm, where the skin is thin, I had an excellent light-sensitive and suitable object for the experiment. The task now was to expose this skin to the strong light of the

80 amp lamp in such a way that certain parts of the skin are affected by all rays, while other parts of the skin are only affected by individual regions of the spectrum. With this intention, I applied to my arm a rock crystal plate, a series of differently colored pieces of glass, some letters and stripes painted with ink, and an ointment whose protective effect I wanted to investigate. All these items and colors were applied to the arm in such a way that the skin surrounding each figure was unrestrictedly influenced by all rays of light; for in this way, the effect of each individual covering object could be most easily observed for the purpose of comparison. After the various items were arranged on the arm, the rock crystal plate and the pieces of glass were adhered with a small drop of fish glue, and the arm was photographed before being exposed to the light.



was. Above, I enclose a print of the photograph; on it, one can see, looking upwards on the arm, near the elbow, a round rock crystal plate (1.5 mm thick), followed one after the other by five oblong pieces of glass (2 mm thick); the one nearest the rock crystal plate was red, the second yellow, the third green, the fourth blue, and the

fifth was an ordinary, uncolored piece of glass. Near the skin, one can see a stripe of the applied ointment. In addition, one can see two letters NF painted with ink, and further, a stripe (a bridge), also painted with ink, between the various pieces of glass

The arm, thus equipped, was now exposed to the light of the 80-ampere lamp, the luminous intensity of which was controlled by an ammeter. The experiment was carried out on the evening of May 11, 1897, and lasted from 8:14 to 8:34 a.m. The arm was held at a distance of 50 cm from the arc, at the position most favorable for the light, i.e., at an angle of 45°-50° along the longitudinal axis of the carbons. Furthermore, the arm was held so that the light fell on the skin as nearly as possible at a right angle

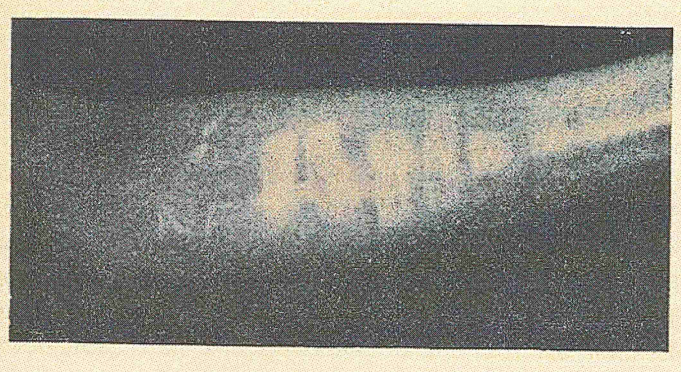
Since the lamp was quite hot, and the experiment would have failed if I had burned my arm, I moved it 75 cm away from the arc after 10 minutes, and then held my arm in that position for another 10 minutes. Then the pieces of glass were removed, and the ink was washed off my arm. The skin immediately appeared somewhat red, even on all covered areas, and equally red everywhere. When examined at 10:12 that same evening, the redness had diminished somewhat, and the skin was still evenly colored overall. When examined an hour later, at 11:30, the redness had increased again, but only in the areas that had not been covered. However, the difference was still very slight, and my experiment book only mentions that the two letters were very unclear

The next morning, however, the result was visible in sharp lines on the skin. It was now dark red and warm and somewhat, but not very, sensitive to the touch

ly. Wherever the skin had been covered with ink during the experiment, it now appeared completely white and normal, standing out sharply against the red surroundings; the two letters appeared very clearly white on a red background. Where the ointment had been, the skin also appeared white, as did where the five pieces of glass had been, with five white stripes of the same irregular shape as the pieces of glass being visible, and the skin of these pieces similarly appeared completely normal. On the other hand, the skin at the spot where the rock crystal plate had been applied had exactly the same color and was just as hot and sensitive as on the uncovered parts. The spot where it had been, however, was clearly indicated by a white ring; the rock crystal plate had not been ground down at the edge, and this uneven edge had scattered the light in all directions, thus preventing it from affecting the skin Furthermore, one could see two patches of almost normal, white skin in the middle of the place where the rock crystal plate had been. I did not immediately understand their origin, but upon comparing it with the photograph taken beforehand, I realized that the isinglass, with which the plate had been stuck, was to blame. The blob of glue may have been somewhat thick, but in any case, it prevented the light from producing a visible effect on the skin. With regard to the glass plates, however, the isinglass played no role, as is clear from the above. The skin was completely the same where the small blobs of glue had been and where the glass alone had covered the skin.

The reddening of the skin persisted strongly for a few days and then gradually decreased. The adjacent photograph, which shows how clearly the effect was noticeable, was taken on May 13 at 3:00 a.m., i.e., two days after the

Effects of light. The photograph was taken on an orthochromatic plate, since the color nuances did not appear quite clearly on an ordinary plate. When the redness had almost disappeared, the skin began to peel off in the form of very small scales, like bran. The peeling lasted several days (from May 20 to 26). The skin then appeared very pigmented, and the pattern visible in the photograph now appeared, if possible even more clearly, white on a brown background.



I noted that at the beginning of August (21% of a month later), the two letters on the arm could still be clearly read. In October, the letters were no longer visible, but the white stripes formed by the pieces of glass could be distinguished, albeit indistinctly

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The experiments reported here coincide in some respects with two earlier experiments, namely by Widmark 1) in Stockholm and by me. Widmark's beautiful

1) Widmark: Hygiea, Festband No. 3

The series of experiments, which I have repeatedly mentioned before and through which it was scientifically proven for the first time that it is the ultraviolet rays of light that cause light erythema, showed how different the effect of light is when it has passed through glass and when it has passed through rock crystal. In none of his numerous experiments did he obtain a photochemical effect on the skin when the light had passed through a glass plate. A glass plate, as is well known, absorbs most ultraviolet rays, while a rock crystal plate allows them to pass through. My experiment has therefore completely confirmed the correctness of Widmark's results

In addition, this experiment partly coincides with one I conducted a few years ago. I painted an ink belt on my arm and then exposed it to sunlight for three hours; as a result, the skin became red and inflamed everywhere, only where the black paint had provided protection was a belt of white and normal skin visible. After a few days, the redness disappeared, and the skin was now pigmented everywhere where it had been red and inflamed. I then exposed the same arm to sunlight again, but without ink, and now the white skin belt became inflamed, while the pigmented surroundings remained unchanged. Through this experiment, I provided evidence of the importance of skin pigment as a protective agent against the rays of light, and thereby answered the often-disputed question of the cause of the black color of Negroes. I have mentioned this earlier experiment in such detail because I find it interesting to make comparisons between the effects on the skin in both cases

1) FINSEN: Hospitalstidende, July 5, 1893, and: On the Significance of Chemical Rays of Light for Medicine and Biology. Leipzig 1899, p. 13.

A comparison may be permissible here, namely that it is the same skin, even the same arm, that has been exposed to two different types of light. I emphasize this in order to simultaneously draw attention to the fact that there are such great individual differences in the skin's reaction to the effects of light that a comparison between two different people would be incorrect

But back to the point: the inflammation that appeared on my skin after exposure to sunlight for 3 hours (the experiment was conducted from 12 to 3 a.m. in the first half of August) was not as severe as that which appeared after exposure to electric light (an 80-amp lamp, a distance of 50-75 cm) for 20 minutes. This superiority of electric light is certainly of great practical importance for light therapy, but it must be remembered that one cannot conclude from this that the electric light was more than 9 times as strong as sunlight; one can only say that it was — more than 9 times richer in ultraviolet rays

My experiment further demonstrated very convincingly the difference between the effect of heat rays on the skin and chemical rays. The heat rays immediately cause a more or less intense redness on the skin. This redness is strongest in the first moment and then decreases. The chemical rays, on the other hand, cause almost no redness at all; it only appears after a few hours and reaches its maximum 12 to 24 hours after exposure. In my experiment, the heat, as mentioned, was very intense for the first 50 minutes, so the skin was immediately very red, and just as red on the areas covered with ink as on the rest of the body

Part; after 2 hours, however, the skin had already become much paler. Thus, the heat rays were to blame for this redness. One hour later, 3 hours after the end of — the experiment, the redness of the skin had increased again; only the areas covered with ink, glass, and ointment were now less red than the surrounding areas, became less and less red, and the next day showed completely white skin, while the redness of the surrounding skin always increased simultaneously, reaching its peak the following day. The chemical rays were therefore to blame for this redness.

The experiment with the letters shows how completely localized and sharply defined the inflammation caused by the chemical rays is.

It is also interesting to see that 20 minutes of illumination could cause such strong and lasting pigment formation that it was still visible after half a year

Finally, there is the experiment with the ointment. This was carried out with the intention of possibly being used by a patient whose skin was particularly sensitive to the effects of light. The ointment consisted of ungventum glycerini colored with evaporated franguladecoct. This was supposed to have a protective effect because of its brown color, which was indeed the case. Incidentally, the ointment was not used, and the interest in the experiment with it essentially coincided with the experiment with the ink drawings.

I did not achieve my intention with the differently colored pieces of glass through this experiment, as the skin under all of them, even under the clear glass, appeared completely the same and apparently completely unaffected. This result showed, as stated above, extremely clearly that the redness that appeared on my skin was exclusively

was due to the ultraviolet rays, as well as the fact that the visible chemical rays had no effect.

Meanwhile, one cannot conclude from this that visible chemical rays cannot cause photochemical inflammation; one can only say that the light used was either not strong enough, or that the experiment did not last long enough. That visible chemical rays, or rather, that light filtered through glass lenses several to one inch thick, can cause photochemical inflammation of the skin, is a daily experience in the treatment of skin diseases with concentrated light, both when using electric light and sunlight. Even if the light, in addition to the four thick glass lenses in the used collecting apparatus, is also supposed to pass through a solution of methylene blue or an ammoniacal solution of sulfuric acid of copper oxide, which solutions absorb most ultraviolet rays, a clear and often severe photochemical inflammation is still observed, followed by pigment formation

Incidentally, to investigate this latter relationship, I also conducted some experiments with sunlight on my arm. I concentrated the light through a rock crystal collecting apparatus, which consisted of a conical metal container, one end of which was closed with a rock crystal lens 10 cm in diameter and with a focal length of 22.5 cm, and the other end of which was closed with a flat rock crystal plate 7 cm in diameter. The intermediate layer of water was 13 cm thick. With this apparatus, the light was collected on the skin, and by holding different colored pieces of glass in front of it, different lights were produced. First, I tried with rock crystal.

alone, then with clear glass, blue glass, green, orange, and red glass, each color for five minutes.

At the same time, the illuminated area was sprinkled with a stream of cold water. In view of the difficult, not to say impossible, task of making all ratios (the percentage light intensity, etc.) the same for all colors, I chose the scale of making the light spot exactly large enough so that I did not feel the heat.

As a result, the spots in front of the different colors became very different in size (from 2-7 mm in diameter).

The result of these experiments was that the skin reacted with the usual photochemical inflammation at the three spots where the light had acted through the rock crystal, the clear glass, and the blue glass, while not the slightest reaction appeared with regard to the other colors. The intensity of the skin reaction followed the same order,

1) The light measurement, which was carried out during the experiment with Vogel's photometer, showed No. 12 after one minute of exposure.

The absorption ratios of the glass pieces were kindly determined by our physical collaborator, Candidate Mag. Absalon Larsen, who informed me the following:

The light glass allows approximately 90% of all visible rays to pass through. A narrow red section was evidently more attenuated, with only 80% passing through. This is where the blue-green tone in the transmitted light comes from.

The red glass allowed 28% of the outermost red rays to pass through, 23% of the middle ones, and 4% of those closest to the yellow ones. All other rays were completely absorbed.

The yellow-red glass allowed approximately 13% red, 5% yellow, and 2% green to pass through.

The green glass allowed a trace of yellow light, approximately 13-15% green light, and very little blue light to pass through

The blue glass allowed 33% of the red to pass through in a narrow section, then almost none of the remaining red; about 3% yellow, 7-8% green, and further increasing evenly to about 40% violet.

was strongest for the rock crystal and weakest for the blue glass. The size of the light spot with respect to these three was as follows: for the rock crystal 7 mm, for the light glass 4 mm, for the blue glass 2 mm in diameter. (For the other colors, the spot was only 2-3 mm in diameter.) I repeated the same experiment on another day with the same result

During these experiments, I observed that the red spots that appeared on the skin rose above its level; they appeared like flat, hyperemic spots whose edges rose sharply above the normal skin. At the same time, I must add that no blisters formed, so no detachment of the epidermis was responsible for the elevation.

The experiments reported here not only confirm the results obtained by Widmark, they also expand on them.

I will, however, return to the first experiment with the light from the 80-amp lamp on my arm. This experiment was of great importance for

1) The method I chose here, making the spots so small that I couldn't feel the heat, apparently doesn't look as good as if, for example, I had made all the spots the same size; in fact, however, the latter would have been much more inaccurate due to — the different absorption ratios of the glass pieces. It is quite interesting to note from the results that the reaction was strongest where the conditions were apparently most unfavorable (when the same amount of light is concentrated on a large spot, the conditions are naturally less favorable than where it is concentrated on a small spot). In the experiment with the rock crystal, the light spot was 7 mm in diameter, and here the reaction was strongest; for the green, orange, and red glass, the spot was 2-3 mm in diameter, and here no reaction occurred at all. Incidentally, I must point out that I only consider these experiments to be of significant value in answering the question of whether it is exclusively the ultraviolet rays that cause the photochemical reaction on the skin.

me when I became aware of the remarkably strong effect of ultraviolet rays and the great importance it would consequently have for light therapy with concentrated light to use collecting apparatus with rock crystal lenses instead of glass lenses. One must assume that the ability of light to induce inflammation, in addition to its ability to kill bacteria, is of great importance for therapy. However, since I saw the severe inflammation of the skin beneath the rock crystal plate, an inflammation that was apparently just as severe as on the uncovered skin, I wondered whether ultraviolet rays might also have a correspondingly powerful effect on bacteria. 1) Therefore, I conducted some experiments with light through a collecting apparatus with rock crystal on a culture of Prodigiosus sown on a rock crystal plate This was followed by the demonstration of an extraordinarily great bactericidal ability of these rays. A more detailed investigation of this relationship, along with the ability of the other radiation qualities to kill bacteria, was carried out by my assistant Dr. Bie, to whose excellent investigations, presented in this book, I would like to refer.

I made yet another observation following this simple 20-minute experiment on my arm. I mentioned above that approximately four months after the experiment, the skin was so pigmented that the white stripes formed by the glass stripes were indistinctly visible. A few months later, they were no longer visible, and the skin on the arm was completely uniform in color, with no markings.

1) As I already mentioned in my treatise: On the Application of Concentrated Chemical Light Rays in Medicine, p. 6, opinions on this matter have been very different to date

One morning, however, as I was rubbing my skin as usual, I noticed that the pattern on my arm reappeared, so that the parts of the skin that had been protected by the glass strips did not become as red as the surrounding areas due to the rubbing. This can only be explained by the fact that the dilation of the capillaries and vessels of the skin, which is a result of the effect of chemical rays on the skin (I had previously examined this microscopically on the tail of the tadpole), 1) was partially maintained, so that it was still detectable 5-6 months after its induction, and even after the skin pigment had disappeared

This dilation of the skin capillaries, whether called pathological or normal, appears, although hardly to such a high degree as here, through any reasonably strong exposure to light on the skin; and that it has a certain beneficial effect on the skin is beyond doubt. One could well assume that more blood flows to the skin, or that this would at least be possible, when the capillaries are dilated, and furthermore, that the skin is better nourished and consequently becomes more functional again. 2)

If it is the case that a frequent but not so

1) FINSEN. Hospitalstidende d. November 1, 1893

2) In this context, I would like to draw your attention to some older, very interesting studies by Berthold. He found that nails grow faster in summer than in winter. The same nail that needs 116 days to renew itself in summer needs 152 days in winter. Hair growth is also more abundant in summer than in winter, and during the day than at night. (Müller's Archives for Anatomy and Physiology 1850, p. 156). That this is true with regard to beard growth, and that the difference is quite significant, I have received confirmation from various barbers through inquiries. They declare it a fact well known to all barbers that one does not need to be shaved as often in winter as in summer

Since intense lighting has the same effect on the capillaries of the skin, we must expect a greater blood filling, or the ability to fill with blood, in those parts of the skin that are daily exposed to light than in those parts that are always covered by clothing, and this is indeed what we find.

The face, neck, and hands of most people are, as is well known, of a much stronger color than the rest of the skin, and there is often a very sharp color boundary between the covered and uncovered skin. That this is not only characteristic of the face, neck, and hands, but of the skin in general, can be clearly seen in children and in people who walk with bare arms and knees; the skin color always changes right up to the area covered by clothing.

This strong color is, of course, largely due to the skin pigment; but it is usually easy to see that a considerable part is due to a more abundant blood supply

In albinos, the blood is solely responsible for this skin redness, and in very blond people, it is almost exclusively the blood. In autumn and towards winter, when the skin pigment begins to fade, it also becomes clear that the blood supply plays a major role in skin color, even in more pigmented people. Incidentally, even if the skin is very pigmented, one can usually see whether the pigment alone or also the blood supply is to blame for the skin color. If, in addition to the pigment, there is abundant blood supply to the skin, it appears a warm, reddish-brown color; if, on the other hand, pigment is primarily responsible, the color is grayish-brown and cold. This is often observed in the same person at different times.

This reddish color of the skin described here can

can probably be considered such a constant phenomenon that it can be considered a fact that the part of the skin that is not covered and which (at least in summer) is exposed to light and air in a normal way will acquire a more intense red color than the covered skin. Special conditions apply to the cheeks; these are very often red, even when the rest of the facial skin, which has been exposed to the same external influence, is completely white. The red color of the cheeks must therefore be considered something special, a racial peculiarity

Meanwhile, it does not follow from this, although it seems from my light is to blame for this skin redness. — investigations that According to the previously accepted view, one would rather say, at least with regard to the particularly strong forms, e.g., the complexions of sailors and landowners, coachmen, and generally people who spend a lot of time outdoors, that wind and weather are to blame. Analyzing wind and weather, however, is not so easy, because even if light is included, i.e., in the form of heat (identical to the expression "sunburnt"), one still largely thinks of air and water, especially in the form of storms, rain, or snow (identical to the expression "weather-beaten")

One can assume that rain and wind work primarily through the cold or warmth they possess, but to a much lesser degree they work mechanically through the force that acts on the skin, whipping it, so to speak. While we can therefore safely disregard the mechanical moment without harm, the relationship is quite different with cold and warmth.

The powerful influence of cold and warmth on the expansion and contraction of the vessels and capillaries

are phenomena that have long been known and irrefutable. Their significance for this question will therefore generally hardly be underestimated, whereas it will be more difficult for light, which has so far been treated so neglectfully, to have its contribution to this phenomenon recognized. The situation here is the same as with two other phenomena caused by light: the formation of pigment in the skin and solar erythema. It was believed that "wind and weather" were to blame for the pigment formation and that solar erythema was caused by the sun's heat; but now we know that the chemical rays of light are to blame for both phenomena

According to my observations, chemical rays have the ability not only to cause the already well-known acute redness of the skin, but also a permanent dilation of the skin capillaries. On the other hand, there is hardly a more well-known phenomenon than the strong redness that appears on the skin after exposure to both intense heat and intense cold. Precisely for this reason, however, analyzing how large a share in the skin redness 1) one or another of these three agents has is very

1) When mentioning physiological skin redness, one must not mention the interesting "blushing," which is due to psychological causes. In Darwin's *The Expression of the Emotions*, 1872, where blushing is made the subject of investigation, there are several things of interest to us. Darwin says (p. 315): "It is an interesting question why only the face, ears, and neck mostly become red, although the sensation and feeling of warmth often extends over the surface of the whole body. This seems to depend mainly on the face and adjacent parts of the skin having been habitually exposed to air, light, and changes of temperature, whereby the small arteries have not only become accustomed to being slightly dilated and contracted, but they also appear to be unusually well developed in comparison with other parts of the surface. This opinion is, moreover, confirmed by the fact that certain races which go almost naked often blush on the arms, chest, and abdomen."

be difficult, since an isolated effect cannot be easily carried out.

If I will attempt such an analysis in the following, it is not because I underestimate the difficulties involved (it is especially important to remember that agents other than the three mentioned here may also have an influence), but because I can thereby make other contributions to the solution of the question. Let us first consider the reddening of the skin caused by heat, of which we can probably establish two types: a direct and an indirect

One, the direct one, is "heat — erythema," which is caused by the local exposure to intense heat. It is based on a paralysis of the muscles of the skin vessels and, in contrast to light erythema, appears immediately after the exposure and, likewise in contrast to light erythema, disappears very quickly, depending on the intensity of the exposure, sometimes after a few minutes, sometimes after a few hours.

Heat strong enough to cause such erythema does not exist in the medium surrounding us, at least not in our climate, so we can completely disregard it when we sprechen.com of the natural redness of the skin

The other type of redness of the skin, which can arise from the effects of heat, is of greater importance to us; it appears when the heat of the body becomes too great, either due to the heat of the surrounding air or due to increased heat production within the body itself, and the blood rushes to the skin. Now, one might think that if this process were repeated very often, a permanent redness of the skin would appear. This, however, is not the case; the opposite seems to be true

something we can see in people who are particularly exposed to greater heat, e.g., bakers, stokers, metal founders, whose pale complexions are characteristic. Europeans who settle in the tropics are also said to usually develop a pale or sallow complexion, although their skin becomes more pigmented.

We therefore see that heat mostly seems to play a negative role in the etiology of skin redness.

The relationship with cold seems to be different. The first phenomenon when the skin is exposed to cold is, as is well known, a contraction of the skin muscles and vessels, so that the skin turns white; But later, especially after a long and intense exposure to cold, a reactive, strong reddening of the skin appears, the duration of which corresponds somewhat to that of the heat erythema (since all can usually be calculated in minutes or hours, in contrast to the light erythema, whose duration must be calculated in days). While the reactive reddening of the skin itself quickly disappears in each individual case, it could happen that frequent repetition of this process—in contrast to the heat exposure—produces a permanent red color of the skin. I cite, for — example, the complexion of coachmen — and sailors in winter. The same parts of the skin that are under the influence of cold are, however, also exposed to light, which makes it difficult to determine how much is due to one factor and how much to the other.

We know that strong light, even without the aid of cold, can produce a fairly permanent redness (light erythema).

1) C. LANGE: Almindelig patologisk Anatomi. 1896. P. 60.

can; but that even frequent exposure to not so strong light, without erythema ever having been present along with — pigmentation, can produce a reddish color of the skin, I have often had the opportunity to observe after sunbathing and electric (photochemical) light baths, which we use in the Light Institute. To what extent, on the other hand, cold can produce a permanent, normal reddening of the skin without the mediation of light is more difficult to determine. Since it must be considered irrelevant whether the cold acts in the form of cold air or cold water, one could perhaps expect to gain some insight into this by examining the effect of frequent cold baths, e.g This has been observed, for example, in cold plunge baths or especially cold foot baths (since these require prolonged exposure to cold). As is well known, however, the skin does not acquire a significant, lasting red color, at least not a color comparable to that of uncovered skin. However, with these baths, the relationship is such that the skin is covered by clothing between exposures to cold, which could possibly make a difference, and for this reason, they can only be compared with the light baths, whose effects on the skin I just mentioned.

On the other hand, one might also be able to learn something about the uncovered parts of the skin by examining how North Pole explorers fare, who are exposed to very severe cold and, at the same time, have to live in the darkness of the polar night for several months of the winter. It is fortunate that some studies on the color of skin after wintering have just been published from a polar expedition; namely: "Undersökningar till förklaring af hudfärgens anmärkta förändring efter öfvervin-

Investigations into the explanation of the perceived change in skin color after wintering in the polar regions, carried out during the last Swedish expedition to Spitsbergen by their physician R. Gyllenkreutz and communicated by Frithjof Holmgren. (Upsala läkareförenings förhandlingar 1883-84, p. 190).

Holmgren writes: "Those who took part in the earlier winterings in the polar regions have often perceived a changed skin color as a peculiar phenomenon, which appears when daylight returns after the long winter night and which gradually disappears again

It should suffice here to cite a few comments on the observed effects of the winter night as daylight approached. 1) Kjellman describes the relationship as follows (translated from Swedish): "How bright we found it outside in the first days of February, and how strange it seemed to be able to clearly distinguish the surrounding objects again in the open air, to see ourselves and the comrades standing or walking nearby. We also observed each other with great attention. We had all, of course, undergone changes in the past time. With our yellow-pale, flabby, emaciated, bearded faces, we no longer resembled the same people from the summer; the influence of darkness was clearly and distinctly evident!" In the doctor's report, which Kjellman 2) cites, it says:

1) F. R. Kjellman: Swedish Polar Expeditions 1872-73 led by A. E. Nordenskjöld, p. 226.

2) Cited in the same book: pp. 232, 233.

about the same: "The winter climate in Spitsbergen, which in terms of severity cannot be compared by a long way with that of the North American Archipelagus or Siberia, could, on the other hand, be considered less healthy due to the prolonged low temperature, the frequent storms and snowstorms, the strangely rapid changes in the weather, and above all, the unbearable darkness. The effects of these varied somewhat from individual to individual. In some, drowsiness, indifference, and weariness developed; in others, a striking irritability of the mind with a generally strong moodiness; some complained of sleeplessness at night and great tiredness during the day; and in all, without exception, a more or less pronounced chloroanemic condition developed. When the sun returned, the prevailing complexion was pale, bordering on yellow-green, like that of plants grown in a dark room with insufficient light. Another effect of the long Arctic winter, which which could be indirectly attributed to the darkness, and which depended more directly on the anemic condition, was a generally prevailing dyspepsia, a kind of atony of digestive efficiency," etc.

As can be seen from this, the altered skin color, which Kjellman describes as "pale yellow" and the doctor as "pale, bordering on yellow-green," seems to be a constant consequence of overwintering, and which, based on the statements cited, of all the contributing factors, is mainly attributed to the influence of the darkness.

Holmgren next recounts how, in Uppsala, during a discussion about this altered skin color, the remark was made as to whether it might not possibly be a subjective phenomenon and due to a change in the color sense in the patient

observer, caused by the fact that the eye had to go without daylight for so long. Therefore, it was decided for the upcoming expedition to Spitsbergen to investigate the extent to which the change in skin color was an objective or subjective phenomenon. The investigations were carried out by the doctor Gyllenkreutz in such a way that, upon the return of the sun in spring, one of the expedition members was to remain continuously in the dark until the skin of the other members had regained its natural color. The engineer Andrée volunteered to participate in this painful experiment. Gyllenkreutz wrote about it in a report (written in March 1883 on Spitsbergen): "January 24, 1883, was the first day on which a greater twilight appeared. Mr. Andrée (AÉE) had willingly offered to remain in the dark and artificial light until the rest of us had acquired a normal color through daylight. He began his torture that same day

On February 21, the light corresponded to an ordinary winter day in Sweden. We observed the sun from a 1,500-foot-high mountain. At noon, a general examination was made, and the complexion of each participant was determined by all the others, and the person concerned could check their judgment in a mirror. The verdict was unanimous: they all had a white, already delicate, slightly pink color, rosy-tinged, as one might say. Only one person (EM) had a very slight nuance of yellow-gray on the nostrils. Then AEE came out and had to first pronounce on the color of each individual, and his judgment was entirely in agreement with ours. Then he was compared with the others in turn, and we all found, including himself (through the mirror), that his color varied quite a lot in the

yellow-gray, although he had pretty pinks on his cheeks

I have reported on these examinations in considerable detail because they are very peculiar and of great interest for the question being discussed here. It turns out that everyone, even Andrée, had "roses on their cheeks," and while Andrée's complexion was somewhat yellow-gray, all the others had a white, albeit delicate, color, somewhat shifting into red. In another passage where the details of the assessment are mentioned, the expressions "he was pale like a city girl," "white," and "red, just like a delicate city lady." If one disregards the cheeks, for which, as previously stated, very special conditions apply, one is undeniably somewhat astonished that these people, who had been exposed to the excessive cold and unfriendly weather of the polar regions for an entire winter, all had a "white, almost delicate color." Of course, we must not forget that these people may have had some anemia; according to Gyllenkreutz's statements, however, it was only to a slight degree.

Be that as it may, these investigations do not indicate that cold alone plays a major role in the appearance of skin redness. However, since we see every day that people exposed to both cold and light develop a very deep red skin color, especially much more so than those exposed to sun and warmth, it does not seem unreasonable to assume that cold promotes or supports the appearance of the skin's red color

Finally, I will briefly recapitulate and clarify what was achieved through these investigations.

1) The accuracy of Widmark's investigations into the effect of light on the skin has been confirmed and further expanded in that visible chemical rays also have the ability to induce the peculiar photochemical inflammation.

2) It has been proven that in electric light, the strongest bactericidal ability belongs to the ultraviolet rays, and as a practical result of this phenomenon, the necessity has arisen to use exclusively quartz lenses for electric light-collecting devices; and this change has led to very great progress in treatment with concentrated light.

3) I have demonstrated that the expansion of the skin capillaries caused by chemical (ultraviolet) rays is long-lasting, and it has been macroscopically detectable approximately half a year after exposure to light

4) A compilation of the various factors acting on the skin has shown that the normal reddish color, which every skin gradually acquires when not covered, owes its origin, if not exclusively, then at least to a great extent to light, i.e., to the chemical rays of light. The development of the reddish color of the skin appears to be inhibited by the effect of heat and promoted by the effect of cold.

For the study of the physiological effects of light, the demonstration of points 3 and 4 represents a good step forward. For whereas previously, when discussing the effect of light on the skin, only acute reddening of the skin was recognized, and pigmentation was considered the most essential or sole chronic effect or consequence of light exposure, chronic reddening of the skin has now been added as a phenomenon that is also due to light exposure.

The reason that this chronic effect of light has been overlooked so far is undoubtedly that the simultaneously occurring skin pigment has usually been noticed and occupied all attention, as well as the fact that the pigment partially covered the red color of the skin. On the other hand, in cases where only very little pigment was produced and therefore a distinct reddening of the skin, or where the pigment disappeared and the reddening of the skin became more apparent, this effect has usually been attributed to factors other than the chemical rays of light

So we have taken a step forward, but the step is not complete because we do not sufficiently understand the importance of an abundant blood supply in the skin. We can conclude from this that the skin is better nourished and can perform its functions better; however, we do not yet know exactly what these functions are. Only when we know these will the significance of the effect of light become clear to us, and we will then certainly have to acknowledge at the same time that in the chemical rays of light we have a means—perhaps the most powerful we have—to help the skin's functions through 3

the use of light baths. Finsen's Medical
Light Institute,

At the Light Institute, we have been conducting some experiments for some time—but essentially for a different reason—with the therapeutic use of such photochemical light baths (sunbaths, electric light baths). However, our material has been somewhat limited so far, and we have not yet progressed beyond the experimental stage.

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1) By these, I naturally do not mean the incandescent light baths or weak arc light baths that have been so widely used recently, but rather very strong arc light baths (100-ampere lamps). See, incidentally, my remarks on light baths: On the Significance of the Chemical Rays of Light for Medicine and Biology. Published by F. C. W. Vogel. Leipzig. 1899. Pages 69-71.

III.

An Electric Incandescent Light Thermostat

by

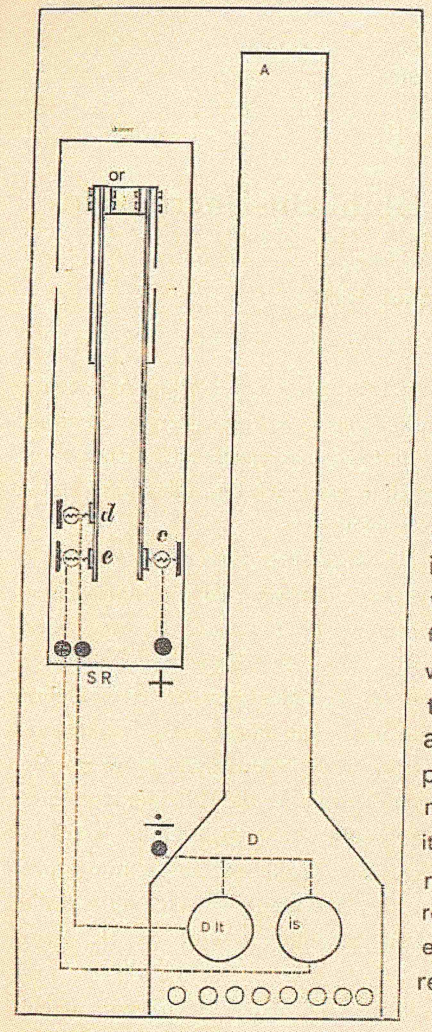
Sophus Bang

Where electricity is available in the laboratory, as I will discuss in more detail below, there are certain advantages to heating the thermostat by means of an electric lamp. To make this possible, I have constructed the following electric thermoregulator.

In principle, it consists of a spring formed by two soldered-together strips of metals with different coefficients of thermal expansion (e.g., steel and brass or steel and zinc). One end of the spring is fixed, and the other carries a small platinum plate on the brass side, which rests against a screw tipped with a platinum tip. The current from the lamp passes through the spring and this platinum contact; as soon as the temperature reaches a certain level, which depends on the position of the screw, the contact is broken due to the greater expansion of the brass, and the lamp goes out; as soon as the temperature later begins to fall, the contact is re-established, and so on

This simple device, which any mechanic can easily make, works very satisfactorily. Each push-

wooden box can function as an improvised thermostat. For years, such a thermostat has been in continuous operation at the



Light Institute. The manufacturing costs for the regulator (including the light bulb) amounted to approximately 8 marks, and the thermostat box (a very simple wooden cabinet, 30 x 30 x 65 cm) cost about the same. The accuracy of the regulation is approximately 12 °C as the largest deviation; for days, the temperature barely fluctuates by 1/50. B A

nevertheless a disadvantage that the incandescent lamp, as is well known, only functions for a certain time; if one wants to be absolutely sure that the lamp will not fail after a few months, perhaps at an undesirable moment, one must replace it more often than otherwise necessary. Partly for this reason, and partly to achieve even greater accuracy and reliability of regulation,

I later had the regulators, which are now also in use

in various other laboratories, set up in the following way.

Two springs (A and B) are attached to a slate plate SS

Spring A has its brass strip on the right, spring B has its left. Near the tip, A has a platinum contact for screw c, B has two for screws d and e. These three screws all have platinum tips. The current enters at , passes through contact c, spring A, spacer m, spring B, and divides at d and e into two branches, each for one of the two light bulbs D and E, after which it exits through the thermostat.

To set this regulator for a specific temperature, say 37°C, one first screws d and e quite far to the right, so that even at too high a temperature these contacts are not broken. C is now set so that the lamps (both simultaneously) go out at, say, 37°C. Now that this temperature has remained constant for a few hours, one turns back screws d and e enough so that the temperature now remains at 37°C These screws can easily be adjusted so that when the thermostat door is opened, lamp E lights up first, followed two seconds later by D. The two contacts d and e actually only take care of the regulation, while screw c, which is set for 37.5°C, always remains in contact. This latter thus serves as a safety device; should one day (which has never happened to me yet) d or e not interrupt the current at the right time, e.g. due to dirt, c already comes into action at 37.5°C. C also has another use. If one wishes to temporarily work at a temperature lower than 37°C, one can very easily set the desired temperature using c, without having to worry about dunde. As soon as one returns to

If one wishes to return to 370, one simply turns it closed again, rather a little too much than too little; d and e then immediately assume their old role without having to worry about setting it to 37°C again.

If, as discussed above, e closes the contact a moment earlier than d, with the thermostat door closed, only e (with lamp E) will function, with E igniting and extinguishing several times a minute. However, as soon as the door is or was opened, both lamps burn simultaneously due to the greater cooling, and the desired temperature is thus reached again as quickly as possible. Finally, d will also become active if the other lamp has burned out, which one notices immediately when the door is opened, as only one lamp then ignites. Lamp E will, of course, ceteris paribus, always burn out first

I use a double-walled wooden box with a double door as the thermostat chamber. The incandescent lamps are mounted in a double-walled or at least tin-lined wooden chimney (R, R) of the shape shown in the figure, partly to maintain the same temperature everywhere, and partly to keep the light away from the crops. I use 25-candle incandescent lamps at a voltage of 110 volts; stronger lamps easily cause excessive sparking at the contacts. Two such lamps are sufficient for a chamber of more than 100,000 cm. The advantages of this apparatus are:

1. Precise and reliable regulation. An accuracy of 1/10 can be easily achieved.
2. The simplicity with which one can quickly adjust to other temperatures.
3. The speed with which reheating occurs after the door is opened.
4. The safety compared to a day and night

burning open gas flame, especially in laboratories, where the possibility of gas explosions caused by it can hardly be completely ruled out.
5. The price is very low (approx. 1/5) compared to commercially available thermoregulators of equivalent accuracy and safety. 1)

As for operating costs, however, the situation varies somewhat, depending partly on the local price of electricity, and partly and mainly on whether the thermostat is installed in a heated room. In the latter case, one can expect a light bulb to burn for a maximum of about 10 hours out of 24 hours. If the thermostat is only needed from time to time, the operating costs can be even lower than for gas, because one only needs to turn on the power shortly before use, whereas an ordinary thermostat must be lit continuously to be operational

1) Mr. Thomsen, electrician, Sortedamsdosseringen 771, Copenhagen N., supplies the regulator for 20 marks; a complete thermostat with a capacity of approximately 70,000 cm^3 for 100 marks

IV.

Investigations into the bactericidal effect of the various parts of the spectrum by Valdemar Bie.

The investigation of the bactericidal effect of the various spectral regions is not only of great theoretical and practical hygienic interest, but also of utmost importance for the therapeutic application of the bactericidal ability of light. It shows which rays should be excluded as useless or harmful, and which, for the purpose of treating patients, should be exposed to light in the largest possible quantities. By using various light sources and light filters, the composition of the phototherapeutic agent can be mastered to the same degree as the composition of any other therapeutic agent.

Earlier researchers of these relationships did not achieve a reliable result, partly because they did not master the physical part of the experiments and partly because they used relatively weak light. I will

The following describe the nature of the experiments and the results, for comparison with the technique developed here at the Institute.

Literature Review.

Downes and Blunt (1877) and 1878 addressed the present question in the two papers in which they first demonstrated the bactericidal effect of light. They cultivated the bacteria in small test tubes with Pasteur's liquid; usually, they inoculated with a liquid containing numerous bacterial species (not pure cultures); sometimes, self-infection was used.

Some of the test tubes were exposed to sunlight, either in boxes made of colored or clear glass; others were exposed directly to sunlight, and still others were packed in light-tight lead plates.

Whether microorganisms were developing could be determined from the turbidity of the liquid, and whether they were bacteria was confirmed by microscopy

In the first series of experiments, no spectroscopic examination of the colored glasses was carried out; in the other, this examination gave the following result: the blue glasses allowed the violet and blue rays, as well as some green and yellow-green rays, to pass through, while the yellow glasses allowed the entire spectrum to pass through, except for the violet and about half of the blue rays. The red glasses allowed the red and orange rays to pass through.

The test tubes in which bacteria first developed were those packed in lead; these were followed by the

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Downes and Blunt: Researches on the Effect of Light upon Bacteria and other Organisms, Proceedings of the Royal Society of London. December 6, 1877, Vol. 26

those in the red box, and shortly afterwards those in the yellow one; no bacteria developed in the test tubes in the blue and the light glass boxes. Downes and Blunt stated the result of the two series of experiments in the following sentences. "As far as our investigation extended, the effect seems to be mainly, yet perhaps not exclusively, connected with the chemical rays of the spectrum." - "That the effect depends mainly on the blue and violet rays is proven by the great difference between the test tubes in the blue and the yellow boxes, the latter allowing all rays to pass through except the violet and a portion of the blue ones." -

Furthermore, the experiment seems to show that the red and orange rays are not entirely ineffective, for the turbidity occurs later in the test tubes in the red box than in those encapsulated in lead, as soon as the nutrient liquid is sufficiently concentrated

If the phenomena were represented in a curve, it would have its peak in or near the violet and quickly decrease into blue or green, but then extend approximately as far as the red is visible.

E. Serrano Fatigati (1879) only reports about his technique that he represented colored light using solutions of fuchsin, nickel nitrate (green), Lyon blue, and Parma violet. He came to the conclusion that violet light favors the development of lower organisms, while green light retards it.

Downes and Blunt: On the Influence of Light upon Protoplasm. Proceedings of the Royal Society of London. December 19, 1878. Vol. 28

E. SERRANO FATIGATI: Influence of various colors on the development and respiration of infusors. Comptes rendus midweekly des séances de l'Académie des sciences, volume 89, 1879, p. 959.

Arloing (1885) conducted some experiments with Bacillus anthracis, cultured in flasks containing uncolored chicken broth. These were placed in a thermostat with a glass door and illuminated by a strong gas lamp, the light from which was collected on the flask by a glass lens. The colored light was produced by passing the light through light filters (glass dishes with parallel, flat walls) containing colored liquids. Control flasks were placed in a dark thermostat at the same temperature

The author summarizes the results of the experiments as follows:

"The presence or absence of artificial white or colored light does not influence the growth of Bacillus anthracis too much; however, spore formation is most rapid in the dark and in the less refractable rays of the spectrum." By this, the author means those flies to the left of the Frauenhofer line, i.e., the red, orange, yellow, and green.

Later, Arloing conducted some experiments on the influence of sunlight on the growth of anthrax spores. He again used flasks of broth inoculated with anthrax spores. The sunlight was directed onto the flasks through a heliostat. The colored light was produced, as before, by light filters containing colored liquids. At night, the flasks were placed on ice, if necessary.

If a light filter was placed in front of the flasks,

M. S. Arloing: Influence of the light on vegetation and the pathogenic bacteria of Bacillus anthracis. Reports of the Académie des sciences. February 9, 1885, tome 100, p. 378.

Arloing: Influence of the sun on the vegetation of the spores of Bacillus anthracis. Reports of the Académie des sciences. August 24, 1885, tome 101, p. 511

which only allowed the red or chemical rays to pass through, the illuminated flasks became clouded almost as strongly and quickly as those in the dark.

A simultaneous investigation of the effect of all colors was achieved by allowing a Pasteur's pipette, prepared as usual, to suspend for 4 hours in all seven divisions of the solar spectrum. The next day, bacteria had developed in all pipettes, while the control pipette, exposed to undivided sunlight at the same time, was sterile.

The author therefore states:

"Consequently, the inhibitory or destructive effect on the developmental capacity of Bacillus anthracis does not seem to depend on individual rays of the spectrum; rather, it is due to the undivided sunlight."

LÜBBERT (1886) worked with gelatin cultures of von Stafyloc. pyog. aur. in test tubes. He divided these into four groups; the first group was placed in a blackened box, the second in a container with double glass walls, between which was a solution of potassium chromate (only allowing non-chemical rays to pass through); the third group was placed in a similar container with copper oxyammonia (only allowing chemical rays to pass through), and the fourth in an empty test tube. All four groups were placed in sunlight near the laboratory window for the same length of time. After 10 days of illumination, no difference could be seen in the appearance of the cultures. After four months of illumination, inoculation was carried out from the test tubes, whereby no difference in energy was

LÜBBERT: The Staphylococcus pyogiosa and the Osteomyelitis Coccus. Würzburg 1886, p. 14. Ref. in RAUM: Biological Significance of Light. Journal of Hygiene. 6th vol., 1889, p. 327.

growth persisted. The author has thus obtained a completely negative result, both with regard to the effect of undivided sunlight and that of colored light.

JANOWSKI (1890) conducted experiments with the typhus bacillus, which was inoculated in test tubes as a streak culture on slanted gelatin or agar. The test tubes were lowered into flasks containing colored liquids, with solutions of fuchsin, Bismarck brown, methylene blue, and gentian violet

spectrum of Bismarck brown consisted of red, The orange, and yellow rays and half of the green. The spectra of the other solutions contained all parts of the solar spectrum, only in different amounts. 1) In addition, two test tubes were placed in flasks containing distilled water, one of which was wrapped light-tight.

The flasks were placed 30 cm from the window in a cold room, with the inoculated surface of the gelatin facing the light. In experiments with diffuse daylight, the author found that the development of the bacteria was much faster and more vigorous in the dark and yellow flasks than in the others; within these two groups, the difference was smaller; growth was better in the dark flask than in the yellow one, and better in the red and blue than in the violet one.

Janowski then conducted experiments with direct sunlight. For this, he used test tubes containing bouillon

JANOWSKI: Centralblatt für Bakteriologie und Parasitenkunde. 8th vol., 1890, p. 167.

1) The spectrum of a non-monochromatic solution is always composed of two or more colors, so that, for example, the spectrum of methylene blue consists of a blue and violet section, which contains a large part of the blue and violet rays emitted by the light source, as well as a faint green and yellow part and a very faint red part

Cultures of the typhus bacillus, otherwise the same procedure as in the previous experiments. In addition to the four colored liquids mentioned previously, a solution of potassium bichromate was used, the spectrum of which included the red, orange, and yellow rays, as well as the beginnings of the green

The test tube standing in the dark and the one standing in the dichromate of potash became cloudy after 8 hours; in the other test tubes, the broth remained clear for the duration of the experiment (5 days). The bacteria thus developed just as well behind the dichromate of potash as in the dark; consequently, the rays absorbed by the dichromate of potash, namely the chemically active rays, are harmful. In another experiment, a test tube containing a typhus broth culture was placed in a flask containing gentian violet. At the same time, one test tube was placed in a flask containing Bismarck brown and another in a flask containing fuchsin. After 2 days, a strong cloudiness developed in the test tubes containing Bismarck brown and the dichromate of potash. Those that had stood in the fuchsin and gentian violet, however, were sterilized during the same period

SANTORI (1890) presented almost monochromatic light through two colored glass plates mounted in a wooden frame 5 cm apart; a test-tube gelatin culture was suspended between the glass plates and exposed to sunlight. The experiment was carried out simultaneously with red, violet, and unstained glass. Cultures of the typhus bacillus, Stafyloc. pyog. aur., and Spirillum cholerae asiaticae were used.

SANTORI: Bulletino della Academia medica di Roma, vol. 16, 1889-90, p. 386

It was shown that undivided sunlight has a powerful microbicidal effect, but that "the violet and red rays of sunlight do not kill the microorganisms, nor do they produce any visible change in their development."

Raspe (1891) found that blue and yellow rays limit the developmental capacity of anthrax spores, while green, violet, and red rays have no discernible effect.

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Geisler (1892) placed some test tubes containing gelatin streak cultures of the typhus bacillus in the infrared, red, yellow-green, violet, and ultraviolet parts of the solar and electric light spectrum. The same was represented by two prisms of flint glass, the type of glass that allows most ultraviolet rays to pass through.

Geisler drew the following conclusion: "All rays of the electric and solar spectrum, except the red ones, inhibit the growth of typhus bacilli; this inhibitory effect is the stronger, the larger the refractive exponent or the smaller the wavelength of the corresponding rays."

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Kotljar (1892) investigated the effect of light on Bacillus pseudoanthracis, Sarcina aurantiaca, Micrococcus prodigiosus, and on a raspberry-red coccus grown on agar and potatoes.

Colored rays were produced by allowing the light to pass through a layer of colored gelatin smeared on the outer surface of the test tubes. Only

Raspe: Influence of sunlight on microbes (Diss.). Schwerin 1891. Ref. in Baumgarten's Jahresbericht, 8th year, 1892, p. 505.

Geisler: Centralblatt für Bakteriologie, 6th year, 11th volume, 1892, p. 161

E. Kotlyar: Wratsch 1892, Nos. 39 and 40, ref. in Centralblatt für Bak-teriologie, 12 vols., 1892, p. 836.

Red and violet light were investigated. The result was that growth was inhibited most by uncolored direct sunlight, less by violet rays, and least by red.

Chmelewsky (1892) investigated pus bacteria using the same method as Geisler. He found that the inhibitory effect of light is not only linked to the actual light rays, but also to chemical and heat rays; the red and infrared rays are the least effective

BUCHNER (1893) made agar plate cultures of Typhus bacilli in dishes to whose bottom a cross or something similar made of light-tight paper was glued; the part of the culture below this served as a control. The dishes were placed, with the bottom facing the light source, in the different parts of a spectrum represented by an electric arc lamp with a parabolic reflector and a quartz prism. Quartz allows the extreme ultraviolet rays to pass through, unlike glass; nevertheless, the author uses glass dishes. The author says of these experiments:

"However, the observations made are too few to draw any reliable conclusions from them. So far, it has only been shown that, contrary to expectations, the development of typhus bacilli in the orange, red, ultra-red, and also ultraviolet ranges remained completely uninhibited, while the brightest part of the spectrum: green, blue, and partly violet, exerted a growth-inhibiting and killing effect on the sown bacteria."

P. Chmelewsky: Wratsch 1892, No. 20, ref. in Centralblatt für Bakteriologie, 12th vol., 1892, p. 174.
Buchner: Archiv für Hygiene, 17th vol., 1893, p. 179.

Ledoud-Lebard (1893) investigated the conditions of the diphtheria bacillus in the following way: He placed smaller test tubes of 5 mm diameter containing a suspension of diphtheria bacilli on the axis of test tubes of 3 cm diameter. The large test tubes were then filled with either water or a saturated solution of potassium dichromate, or with an ammoniacal solution of copper sulfate. He found that "the bactericidal power is almost exclusively linked to the most refractable rays of the solar spectrum. These are just as effective as the collected white light. The least refractable rays have no bactericidal effect, or at most such a weak one that the suspensions affected by these rays behave in the same way as those kept in the dark."

MARSHALL WARD (1893 and 1894) placed an agar plate containing anthrax spores, covered with a zinc plate, in sunlight; a letter was carved into the zinc plate. He thus used the "Buchner method" in reverse. The sun's rays passed partly through colored glass and partly through light filters containing colored liquids.

No bactericidal effect was detected behind the glasses, which only allowed red, orange, and yellow rays to pass through, but cut off the blue and violet rays; the effect was doubtful behind a green glass, which absorbed most of the red, orange, and blue-violet rays, but allowed the yellow, green, and some of the least refractable blue rays to pass through

LEDOUD-LEBARD: Action de la luminère sur le bacille diphtérique. Archives de Médécine expérimentale et d'Anatomie pathologique. Serie I, tome 5, 1893, p. 779.
H. MARSHALL WARD: Proceedings of the Royal Society of London vol. 52, 1893, p. 393 and vol. 53, 1893, p. 23.

On the other hand, a distinct effect was discovered behind all glasses that allowed most or all of the blue and violet rays to pass through, whether or not they blocked the red, orange, and yellow rays. The result was therefore that the bactericidal effect of the sun's rays was due to the rays of the blue-violet half of the spectrum.

This result was essentially confirmed when the light filters were used with ammoniacal copper oxide solution, which blocked all rays from the red to line b (in the green), and with a solution of potassium dichromate, which blocked all rays from b to the right. This experiment showed that the rays passing through potassium dichromate inhibit growth slightly, but much less than the others.

Ward obtained approximately the same result in later investigations with essentially the same arrangement as the one described here, as well as in the following beautiful experiment:

The spectrum of sunlight or electric arc light was projected onto an agar plate into which the spores and bacteria to be examined had recently been inoculated. Bacillus anthracis, Bacillus subtilis, a violet Thames bacillus, and several other Thames bacilli were examined. The spectrum of electric light was displayed through a quartz prism. The agar plate culture was kept on ice throughout the experiment.

Neither in sunlight nor in electric light did the infrared, red, orange, yellow, or green

H. MARSHALL WARD: Proceedings of the Royal Society of London vol. 54, 1894, p. 472.

H. MARSHALL WARD: Proceedings of the Royal Society of London vol. 56, 1894, p. 315.

rays an effect; this began only at the blue end of the green, reached its maximum at the transition between the blue and violet, and was again restricted in the violet and ultraviolet regions. In electric light, which is very rich in ultraviolet rays, the effect extended far into the ultraviolet as soon as the light passed through quartz; but if a piece of glass was inserted, a large part of these effective rays was cut off

DIEUDONNÉ (1894) prepared agar plates of Microc. prodigiosus and Bacillus fluoresc. putridus in Petri dishes; a paper cross was glued to the bottom of the dishes according to Buchner's method. To visualize the different divisions of the spectrum, he used: 1. an aqueous solution of potassium bicromate, which transmitted the red, yellow, and part of the green rays; 2. a concentrated aqueous solution of copper chloride with the addition of a few drops of hydrochloric acid; it transmitted only the green and green-blue rays; 3. ammoniacal copper sulfate solution, which absorbed red, yellow, and green; 4. 1% quinine sulfate solution with a few drops of sulfuric acid; it absorbed ultraviolet. These solutions were poured onto flat bottles that were placed on the underside of the dishes. The thickness of the absorption layer and the duration of illumination were always the same. Sunlight and electric arc light were used as light sources

Behind the solution of potassium bichromate, growth and pigment formation were just as abundant as in the control plate in the dark; behind the copper chloride solution, a slight inhibition of development was observed, in that pigment formation was weak and slow; behind

DIEUDONNÉ: Works from the Imperial Health Office, 9 B., 1894, p. 405

The copper sulfate solution killed all germs; behind the quinine sulfate solution, there was very minimal growth

In another experiment, Dieudonné placed the dishes in the various sections of a spectrum approximately 2 m wide, represented by an electric arc lamp at 900 standard candles and through a Rutherford prism. In this series of experiments, in addition to Bacillus fluorescens and Microc. prodig., Bacillus coli was also examined. Growth in the ultra-red, red, orange, and yellow parts was very abundant; the pigment formation and trimethylamine development of the first two bacteria repeatedly appeared to be even stronger than on the control plate in the dark. No weakness of growth could be detected between D and E, i.e., in the yellow part of the spectrum; on the other hand, a clear inhibition of development was observed in the green part between E and F, and in the blue, violet, and ultraviolet parts of the spectrum, the plates were completely sterilized

D'ARSONVAL and CHARRIN (1894) illuminated a pyocyaneus culture with bright electric arc light, another with the same light after it had passed through a solution of dichromate of potassium, which robbed it of its chemical rays; then a drop of the culture was inoculated into agar, which was placed in a thermostat. By sufficiently long illumination, the former culture was sterilized, while the latter was not affected.

BILLINGS and PEEKHAM (1895), who worked with typhus and colibacillus, found no particular effect of the

D'ARSONVAL and CHARRIN: Archives de physiologie normale et pathologique 5th series, volume 6, 1894, p. 335.

BILLINGS and PEEKHAM: Science, February 1895, p. 169, ref. in Centralblatt für Bakteriologie. 19th vol., 1896, p. 244.

sunlight passed through red, orange, yellow, or green glass panes (not spectroscopically examined); in contrast, the blue and violet rays killed the bacteria almost as quickly as undivided sunlight.

KRUSE (1895) dried anthrax spores on coverslips, placed these in dishes, and illuminated them with sunlight. From time to time, a coverslip was removed from each dish; the dried spore layer was softened with a little broth and then processed for plate culture. The experiment was carried out on May 3, 1892, in Naples

The remaining ratios can be learned from the following diagram, in which the numbers indicate the number of spores capable of growing.

The duration of illumination	No. 1 freely illuminated	No. 2 illuminated behind 2-3 cm of water	No. 3 illuminated behind 2-3 cm of concentrated aluminum solution	No. 4 behind illuminated behind a spectroscopically pure red glass plate	No. 5 illuminated behind a blue glass plate	No. 6 illuminated behind an opaque plate
Before the experiment 1	∞	—	—	—	—	—
hour 2	∞	∞	∞	∞	∞	∞
hours	10 000	11 000	10 000	∞	∞	∞
3 ,,	64	5 600	4 000	∞	∞	∞
4 ,,	210	1 160	750	∞	∞	∞
5 ,,	0	730	132	∞	∞	∞
6.5 ,,	0	8		∞	∞	∞
10 ,,	—	—	—	∞	11 000	∞
14 ,,	—	—	—	∞	6 100	∞
20 ,,	—	—	—	4 000	0	∞

Later experiments produced a very similar result. The table clearly shows that the rays which

KRUSE: Zeitschrift für Hygiene 19, 1895, p. 322, Chapter 4

pass through the blue glass, have a more powerful effect than the red ones. However, the difference does not seem to me to be so great as to allow the author to conclude that, of the rays of the spectrum, the most refractable ones are primarily responsible for the antiseptic effect of light, because an effect of light lasting 15-16 hours, which has passed through the blue glass plate, corresponds to an effect of the red rays lasting 20 hours; this is not a great difference.

I will go into Beck and Schultz's work (from November 1896) in more detail, as it is the latest in this field and provides a good example of how such experiments should not be carried out. Nevertheless, the authors declare all previous experiments invalid because they were not carried out with a monochromatic light

For their experiments, Beck and Schultz mostly used pigment-forming bacteria grown as streak cultures on agar in test tubes. These were placed in boxes whose only opening was closed with light filters. The liquids used were those specified by Landolt, which produce monochromatic light as far as possible, i.e., light consisting of rays that lie very close to one another in the spectrum. The use of such liquids would be highly recommendable if the rest of the experiments were arranged accordingly. The more monochromatic the light becomes, the more rays are cut off, in other words, the lower its intensity; this can only be remedied by amplifying the light source; but Beck and Schultz only used unconcentrated light: diffuse daylight, direct

Beck and Schultz: On the effect of so-called monochromatic light on bacterial development. Journal of Hygiene, 23 vols., 1896, p. 490

Sunlight and Auer's gas-incandescent light, which was also greatly weakened by absorption and reflection, as the light passed through two or three light filters in succession. Diffuse daylight has only a slight bactericidal effect; if you remove so much of this light through light filters that only a small fraction remains, you naturally have no reason to expect that this residue could harm the bacteria

Shouldn't direct sunlight be so strong that even a small part of it could weaken the growth of bacteria? One can only judge this if one knows the strength of the sunlight used, but it has not been measured; the authors only say that the experiments were carried out in spring and summer. Yet even if the very strongest direct sunlight were used, there is one circumstance that greatly limits the prospect of its strong effect. Admittedly, the boxes with the cultures were placed at a south-facing window (which was often closed), but the authors do not say that they were on a heliostat or at least turned toward the sun. Therefore, it is possible that the test tubes were illuminated for only a very few hours a day, and probable that they were not positioned at right angles to the light rays.

The entire technique is such that one could not expect any harmful effect on the bacteria in advance.

The results of the experiments are quite unclear; I will cite one example here

Experiments with Micrococcus prodigiosus.

1. In test tubes, 3.5 days, plenty of sunshine.

Formation of the pigment + +

Dark. Red . . . . . .

light. . . . . —

[illegible]	[illegible]
yellow + „	—
green „	—
sunlight	almost uncolored.

2nd plate culture, 3 days, plenty of sunshine.

	Formation of the pigment
Dark	+
blue light	±
green „	±
yellow + „	—
red „	—
sunlight	colorless

The colors are arranged according to their effect; + denotes "no or the slightest influence on pigment production, thus the best-developed colony." + denotes a stronger and the strongest effect of light. One gets an idea of the author's lack of logic when one compares the sentence in quotation marks with the following quote: "When judging the influence of light on bacteria, one must not identify pigment production with growth." "Rather, the development of such bacteria and their pigment formation are two different things." This remark is undoubtedly very correct; nevertheless, in their description of these experiments on the development of the bacteria, the authors only mention pigment formation and say nothing at all about the nature of the growth.

The authors' summary of the paper is the following: "As our experiments show, no colored light has a development-inhibiting or killing effect on any of the bacterial species examined."

For the sake of clarity, I have presented the results of the previous investigations in a diagram; + denotes bactericidal effect, no effect, o means that the type of radiation in question was not investigated.

	Ultraviolet	Violet	Blue	Green	Yellow	Orange	Red
Downes and Blunt 1877		+	+	+	+	+	+
Fatigati 1879		±	o	+	o	o	o
Arloing 1885		±	±	±	±	±	±
Lübbert 1886		±	±	±	±	±	±
Janowski 1890		+	+	+	±	±	±
Santori 1890		±	o	o	o	o	±
Raspe 1891		±	+	±	+	o	±
Geisler 1892		+	+	+	+	+	±
Kotlyar 1892		+	o	o	o	o	+
Chmelewsky 1892		+	+	+	+	+	+
Buchner 1893		+	+	+	o	±	±
Ledoud-Lebard 1893		+	+	±	±	±	±
Marshall Ward 1893		+	+	±	±	±	±
Dieudonné 1894		+	+	+	±	±	±
d'Arsonval and Charrin 1894		+	+	±	±	±	±
Billings and Peekham 1895		+	+	±	±	±	±
Kruse 1895		+	+	o	o	o	+
Beck and Schultz 1896		±	±	±	±	±	±

Critique of the earlier investigations

The earlier investigators used, on average, rather weak light sources. It is obvious that if one divides the light and lets each part act independently, one must amplify the light source to obtain the same effect in the same time. This seems to be the earlier

not to have appreciated the value of the researcher. Arloing, however, concentrated the light through a glass lens into parallel rays, as far as I can understand. However, his light source was nothing other than a strong gas flame, i.e., such a weak light that one must, at least now, consider it improbable from the outset that it should have — any discernible effect on bacteria if part of it was removed by colored liquids

Other investigators used diffuse daylight and Auer's gas-incandescent light; these, too, are too weak. The only sufficiently strong light sources are sunlight and powerful electric arc lamps. Sunlight is indeed the strongest light source, but, at least in our climate, it is too variable to be used for a long comparative series of experiments. Electric arc lamps have been used by some authors, but only Geissler and Dieudonné have given the luminous intensity (respectively 1000 and 900 standard lights); this is too weak light

The authors' lack of concern for the physical side of the task is also evident in the fact that almost none of them measured the chemical action of their light source, or, if they used artificial light, stated its intensity and the distance of the culture from it; they only stated that they used, for example, direct sunlight; but its chemical power naturally varies greatly according to the latitude, the month, and the time of day when the experiment was carried out. Anyone investigating the bactericidal power of heat will certainly measure the temperature; in corresponding investigations of light, measuring its intensity has not yet been considered necessary; but it seems to me equally necessary in both cases to make as accurate a measurement as possible.

Measuring the light is especially necessary when one cannot demonstrate a bactericidal effect of all the components of the light. In this case, one cannot conclude, as all authors do, that the components that give no reaction do not actually have a bactericidal effect; one can only conclude that these components have no effect in the light of the applied intensity; in stronger light, they may perhaps have a significant bactericidal ability. Only when the light intensity has been measured can one judge whether the result of the experiment is reliable

Besides strong lighting, there is another key requirement for obtaining an accurate result: that the light has the best possible conditions to penetrate even the deepest layers of the bacteria's food substrate. This requirement was particularly not met by the older investigators. Arloing, for example, needed a broth culture in glass flasks; some of the other investigators used cultures in test tubes. Regarding these, as well as the flasks, when using flowing food substrate or stab culture, a large portion of the chemical rays is lost upon absorption in the food substrate, and this acts like a converging lens, so that only a wedge-shaped portion of the culture, located in the center of the glass, is illuminated

The deficiencies highlighted make it understandable why no fewer than three of the earlier investigators found no effect at all from colored light, and why so few noticed an effect from weakly refractable rays; for, if one organizes the experiment in such a way that the sum of all components of the light either does not harm the bacteria at all or only to a slight degree, it is naturally even less possible to demonstrate a bactericidal ability in the individual qualities of the rays

assign, especially to the less powerful ones, even if they actually have the same effect. The only way to obtain an accurate result is to apply such strong light and allow it to act on the bacteria under such favorable conditions that even the least effective rays can produce a distinct reaction.

Own experiments

I already carried out the present experiments in the spring of 1897. Due to the rapid development of the technical resources of Finsen's Medical Light Institute, it is quite inevitable that they now appear somewhat outdated. Nevertheless, I have decided to present them in a foreign language because, despite their shortcomings, which I myself fully recognize, they seem to me to represent an advance compared to earlier work in this field. It seems to me that I have demonstrated more precisely to which spectral regions the bactericidal effect of light is essentially tied than previous investigators have done, and in addition, I have made a first attempt to make this relationship the subject of a quantitative investigation by demonstrating how great the difference is between the effects of the various spectral regions

The numerical values I found cannot claim to be considered exact. The accuracy of such an investigation suffers from the lack of reliable tools for comparing the luminous intensity in the different parts of the spectrum.

With the physical collaborator of the Light Institute, Mr. Candidate Mag. Absalon Larsen, I attempted to make a measurement using Vierordt's and Glahn's spectrophotometers. However, since neither of them gave usable results in the blue and violet ranges, and they obviously cannot measure ultraviolet at all—precisely the regions that are important—I had to refrain from making such a determination

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I worked with Bacillus prodigiosus in this series of experiments. I chose it because we always use it at the "Light Institute" (see Finsen's book "On the Application of Concentrated Chemical Light Rays in Medicine," Leipzig 1899, p. 21, etc.), and because it has often been compared with other bacteria both here and elsewhere without any significant difference being discovered, so that its reaction can be considered typical. As the light source, I used an electric arc lamp of 35 amps, 46-44 volts, approximately 6000 standard candles. To ensure the adjustment of the current intensity as accurately as possible, the automatic regulation mechanism is supported by an adjustable rheostat

I concentrated the light using an apparatus roughly like the one described in Finsen's above-mentioned book, p. 20. It consists of glass lenses mounted in a brass tube; in one end of the apparatus are three plano-convex glass lenses; the one nearest the light has a diameter of 163/4 cm; all together act like a single lens with a focal length of 15 cm

further. The apparatus is suspended in such a way that its axis forms an angle of 45° with the direction of the carbons, and that the positive carbon tip is exactly 15 cm from the nearest lens. The three matching lenses will then collect all rays emanating from the lamp that strike them into parallel rays. These continue through the brass tube and, at the other end, strike a duckweed (a layer of water enclosed on the sides of the brass tube, at the ends of two large watch glasses). The thickness of the water layer is 17 cm at the edge of the lens; this duckweed collects the parallel rays into convergent ones. As the light passes through the water layer, it is cooled by the water absorbing one of its warmest components, namely the ultra-red rays. This ensures that the bacteria are not so easily killed by the heat

Since there is no actinometer that can measure concentrated light, I had to take a detour when measuring the light intensity. I cut strips from a piece of photographic paper (Aristo paper) and illuminated them partly with concentrated light at a location where the cultures were placed, and partly with unconcentrated light at a certain distance (18 cm) from the carbon tips, and at such a height that the paper was struck by the strongest light rays, those that make an angle of approximately 45° with the horizon. The paper was held behind a photographic instantaneous shutter. The difference in chemical action was demonstrated by testing how many times I should let the instantaneous shutter act to obtain the same blackening of the paper with unconcentrated light as that which appeared when I

opened it twice in the concentrated light. Once I had demonstrated this relationship, I only needed to measure the unconcentrated light at the same point as before with Vogel's photometer to be able to specify the intensity of the concentrated light in one of the commonly used actinometric measures.

If I say that I measured the intensity of the concentrated light, this is not strictly correct; one cannot do so at all, since the marginal rays have a far weaker chemical effect than the rays in the center of the light cones. My measurement applies only to the center of the light cones. The illumination time was so short that these rays just produced a noticeable blackening of the paper when the instantaneous shutter was opened twice; the marginal rays made no impression at all

The small blackened spot produced by the concentrated light was cut out; similarly, pieces of the same size were cut out from the pieces of paper that had been exposed to the unconcentrated light at different times; they were then compared in a dark room under incandescent lamp lighting. The pieces of paper were observed through smoke-tinted glasses to correct any slight color difference. A difference of approximately 1/7 of a second in unconcentrated light was clearly visible.

It was shown that the paper had to be illuminated for twice as long in unconcentrated light as in concentrated light to obtain the same degree of blackening; since the effect on the paper is proportional to the illumination time, the chemical effect is consequently 1:10.

On the paper in Vogel's photometer, No. 12 could be clearly distinguished, and No. 13 and No. 14 could just be seen; I refer to this effect as No. 14

(27.88 light units). I exposed for 1 minute and used filter paper dipped in a 4% solution of potassium dichromate; the paper was freshly prepared.

The intensity of the concentrated light at the location where the cultures were applied therefore corresponds to 10 × 27.88 = 279 Vogel light units. Because of the many sources of error, this result can, of course, make no claim to accuracy. For comparison, I mention that the highest sunlight intensity I found in the summer of 1898 was 57 units for an exposure of 1 minute

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I used agar as the food substrate for the bacteria. The illuminated cultures were plate cultures, prepared in the usual way at 45°C in square flasks. Each flask contained 2 cm^3 of agar, and two vials of prodigiosus broth culture were sown into it. The area over which the agar was distributed was 7134 cm^3; the thickness of the agar layer was approximately 0.5 mm over most of the area; at the edge, where the adhesive force acts, approximately 2 mm.

As soon as the agar had become stiff, the flasks were placed on ice. Since Bacillus prodigiosus can grow a little under these conditions, I left the flasks lying for only a limited time before beginning the experiment—a maximum of 3 days in winter and 12 hours in summer

Before the experiment, I painted a number on the bottle with asphalt paint, indicating the duration of the experiment; finally, I slid a metal case with a round hole of

a couple of centimeters in diameter over the bottle, so that the number was in the middle of the hole. The bottle was placed in a rack so that it was perpendicular to the axis of the light cones, within the focal point at the point where the light cones had a diameter of 2.5 cm. To prevent the bottle from heating up, it was sprinkled with cold water through an irrigator throughout the experiment

When the experiment was finished, for short experiments, the time was measured with a chronograph showing 1/5 of a room — second. The bottle was placed in a dark room at temperature. If the culture had grown, and if it had been illuminated long enough, strong growth was found at the point where the number and the metal case had covered it, whereas weak growth or possibly no growth at all was found in the illuminated part of the culture, i.e., the part that corresponded to the hole in the case and was not covered by the number. This difference in growth caused the number to stand out clearly, so that it could be seen with the naked eye

This method, in addition to the clarity of the reaction, has the advantage of protecting against the two most important sources of error: poor preparation of the culture and excessive heating during illumination. The former error is recognized by the poor growth in the part of the culture protected by the metal case; the latter by the fact that the bacteria are killed in numbers; excessive heating during the experiment is prevented by sprinkling cold water over them.

The experimental order used has several advantages over those of earlier investigators: the light is constant and contains rays with a shorter wavelength than any Finsen Medical Light Institute. 5

other artificial light that could be considered (Auer's gas-incandescent light, for example), and is sufficiently strong that even the influence of the weakest rays can be detected; the disturbing effect of heat rays is excluded; each surface unit of the culture is always exposed to a certain number of light units; the preparation of the culture ensures a constant resistance in the bacteria; the thickness of the agar layer, which is always the same, is so small (approx. 1/2 mm) that its absorption plays almost no role; the detection of even the weakest reaction is very easy.

I produced the various parts of the spectrum by placing a 3 cm wide light filter (a vessel with parallel, flat glass walls) filled with various liquids between the concentration apparatus and the bacterial culture

I carried out two series of determinations: 1. how much time the different spectral divisions need to kill the bacteria, 2. how much time they need to produce the weakest detectable reaction, i.e., to weaken the illuminated part of the culture around the number so much that it grows more slowly than the unilluminated part below the number. The number then just becomes visible on the culture, due to the difference in growth. If the illumination lasted so short a time that the difference in growth is only very slight, this gradually disappears, so that the number becomes invisible. Therefore, I read several times how the culture gradually grew.

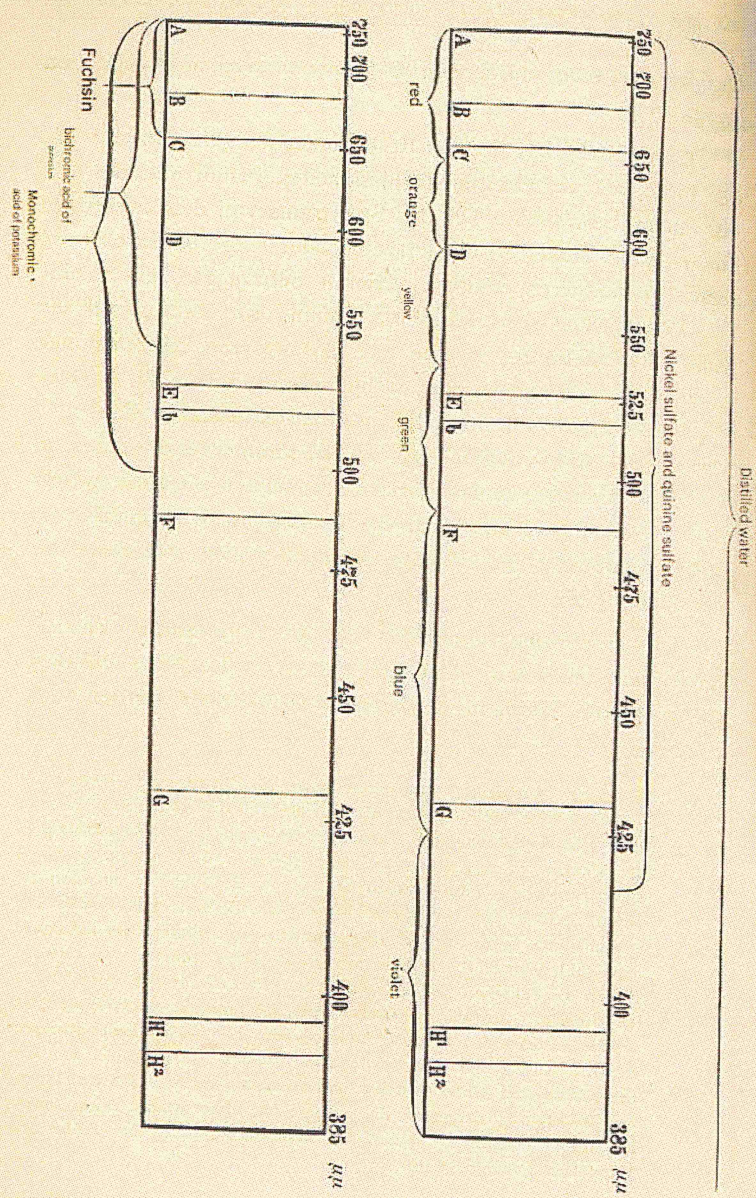
I only carried out these two series of determinations when the light filter was filled with distilled water and thus allowed the qualities of rays to pass

which had actually passed through the concentration apparatus. 1)

I then carried out the same determination when the filter was filled with different liquids, each of which allowed only a specific part of the spectrum to pass a shorter or longer distance from the extreme left end to the right. For this purpose, I used 1. a solution of quinine sulphate with the addition of a little 1% sulfuric acid, 3. a 112% solution of monochromatic acid of potassium, 4. a 1.5% solution of bichromatic acid of potassium, and 5. a 1.7% aqueous solution of fuchsin. I always used a fresh quinine solution, since the strong light quickly turns the solution yellow, probably due to the conversion of the quinine to yellow quinidine. However, the solution did not turn yellow during the experiment.

The electric arc light and the liquids used were spectroscopically examined with Vierordt's spectrophotometer with the assistance of Dr. Absalon Larsen

1) It could miraculously happen that the reaction time I found is not the same as Finsen's (see Finsen: On the Application of Concentrated Chemical Light Rays in Medicine, p. 26); however, one must remember that it is a matter of opinion whether a number is clear and whether the bacteria around it are killed. While Finsen only called the bacteria weakened when the number was very clear, I used as a criterion a number that could only just be seen; and while Finsen called the bacteria killed when almost all were killed, I required that they should be killed up to the edge of the illuminated area and not be allowed to grow out over the course of about a week. The consequence of this is that Finsen's reaction time for weakening the bacteria is higher and his reaction time for killing the bacteria is lower than mine. No one is making a mistake here; it only matters that the reading is the same throughout a series of experiments.



A drawing of the spectroscopic conditions can be found on page 68. I must note that, just as it is to a certain extent a matter of opinion what name one wants to give a color, the boundaries between the colors of the spectrum are far from being as sharp as in the drawing; in particular, the transition between blue and violet is quite indefinite. Therefore, it is quite arbitrary where one draws these boundaries; I have drawn them according to Müller-Pouillet's textbook of physics.

Since neither concentrated light nor direct electric light can be spectroscoped, I converted this into diffuse light by letting it fall onto a frosted glass screen, which was placed 50 cm from the lamp used for the experiments, at right angles to the strongest light rays. If Vierordt's spectrophotometer is turned toward the illuminated part of this screen, it can be seen that the outermost visible red rays have a wavelength of approximately 760 μμ (millionths of a millimeter); from here, the spectrum continues without interruption by the visible rays up to the rays with a wavelength of 434 μμ at the transition between blue and violet; from 434 μμ to 426 μμ, the spectrum is more faint; the rays with a wavelength of 426 μμ to 418 μμ, on the other hand, form a very intense band From here, the spectrum is again faint up to a wavelength of 395 μμ; from 395 μμ to 388 μμ it is dark, and finally ends with a bright band from 388 μμ to 385 μμ; this band, however, is so faint that it is just visible. Whether the light that has passed through the concentrating apparatus contains rays with a wavelength even shorter than 385 μμ, I have not been able to prove with the available resources, but it can be considered likely because electric arc light contains such rays, and because glass, according to Müller-

Pouillet's Textbook of Physics, allows rays up to 350-300 μμ wavelength to pass through.

The different wavelengths were found by examining the position of Frauenhofer's lines in relation to the scale of the spectroscope.

The placement of a light filter containing water in front of the slit does not change the relative spectroscopic conditions to any noticeable degree. The absorption ratios of the liquids used can be seen from the attached diagram; only I must note that there is a difference between the spectrum of quinine sulfate and that of nickel sulfate: while quinine sulfate only slightly attenuates the bright band lying between 426 μμ and 418 μμ, nickel sulfate attenuates it very strongly; this difference in the spectra is not visible in the diagram, which does not give the quantitative ratios

Considering the usual conditions of the absorption spectra, one can assume that substances that absorb violet rays also do not allow ultraviolet rays to pass through.

In order to find the time required for the rays passing through the liquid in question to kill the bacteria and weaken their growth, I first investigated the effect of two illumination times chosen at random and gradually narrowed the interval between them until I found the desired reaction time. I checked this again by illuminating a culture several times at the time found and at a slightly shorter time.

In the following overview, I have presented the figures found in this way together with the spectroscopic conditions.

Because of the long duration of such an experiment, I did not investigate how much time the red light needed to

To kill bacteria. The light passing through potassium bichromate kills the bacteria completely after 10 hours of illumination, but barely after 8 hours. In order not to make another long experiment, I set the time at approximately 9 hours. All other times have been checked by several experiments within the specified time and within a slightly shorter time.

By examining the diagram on page 72 and the drawing of the spectrum on page 68, one sees the following:

All the individual divisions of the spectrum, excluding the ultra-red, which I left out of consideration, have a harmful influence on the bacteria, but to varying degrees. The effect seems to increase fairly uniformly from the red to the ultraviolet end of the spectrum. Where the maximum effect lies cannot be seen from these investigations

The boundary between the chemically active parts of the spectrum (blue, violet, and ultraviolet rays) and the non-chemically active parts (red, orange, yellow, and green rays) corresponds approximately to the right boundary of the absorption spectrum of monochromatic potassium hydroxide. By comparing the effect of the light that has passed through the monochromatic potassium hydroxide (field IV) and the effect of all components (field I) of the spectrum, one determines the main point: how much of the bactericidal effect is due to the chemical rays and how much to the non-chemical ones. The non-chemical rays produce a significant weakening of bacterial growth during an exposure of 6 minutes; the entire spectrum causes the same effect for 1/4 minute, thus acting 24 times as powerfully. If the effect of the non-chemical rays, i.e., the red, orange, yellow, and green, is set at 1, the effect of the entire spectrum is 24, hence that of the

Table I.

a The name of the liquid	b The extension of the spectrum in wavelength	c The color content of the spectrum	d The growth is inhibited by exposure to	e The bacteria are killed by exposure to
I Distilled water	The entire spectrum to the right of 760 μμ	All components of the spectrum	1/4 minute	35 minutes
II 112% solution of quinine sulfate	760 μμ-418	Red, orange, yellow, green, blue, and a little violet. The band 426-418 μμ strong	3/4 minute	80 minutes
III 5% solution of nickel sulfate	760 μμ-418	Red, orange, yellow, green, blue, and a little violet. The band 426-418 μμ is weak.	3 minutes	2 hours
IV 1.5% solution of monochromatic acid of potash	760 μμ-4991	Red, orange, yellow, and almost all green	6 minutes	4 hours
V 1.5% solution of bichromatic acid of potash	760 μμ-541	Red, orange, and almost all yellow	18 minutes	about 9 hours
VI 17% solution of fuchsin	760 μμ-656	Red	90 minutes	not determined

chemical rays, i.e., the blue, violet, and ultraviolet 23. Both groups of light rays, both the

Both chemical and non-chemical rays (not counting the ultra-red rays excluded by the concentration apparatus) inhibit the growth of bacteria, but to very different degrees, with only about 4% of the inhibitory effect being attributed to non-chemical rays, while about 96% is attributed to chemical ones. As already stated above, these figures should not be considered exact; in any case, one can conclude that the vast majority of the effect is due to blue, violet, and ultraviolet rays

As can be seen from the overview table on page 57, it has so far been very doubtful whether red, orange, yellow, and green light rays are harmful to bacteria at all. My experiments show that this is indeed the case. The fact that earlier researchers could not reach definitive results regarding the effect of these spectral components is not surprising when one considers that, despite using extraordinarily strong light, I had to expose the bacteria to these types of rays for a long time to achieve any discernible effect. Pure red light only produced the weakest discernible delay in growth after 1.5 hours of illumination. Considering that this reaction was achieved by illuminating all components of the spectrum for 1.5 minutes, 1.5 hours must be regarded as a particularly prolonged illumination

The light that has passed through the quinine sulphate solution inhibits the growth of bacteria after 3/4 minutes of exposure; that which has passed through the nickel sulphate solution only inhibits growth after 3 minutes of exposure. These two types of light cover the same spectral range, 760-418 μμ, and there is no

other clear difference between their spectroscopic relationships than that the previously mentioned band between 426 and 418 μμ in the spectrum of quinine sulfate is intense and faint in that of nickel sulfate. The great difference in effect is undoubtedly largely due to the different luminous intensity of this band. This relationship is a striking example of the importance of light, whose bactericidal power is used therapeutically, being as intense as possible in its blue-violet-ultraviolet part

Outside the aforementioned band from 426 to 418 μμ, the spectrum is faint from 418 to 395 μμ and dark from 395 to 388 μμ; between 388 and 385 μμ lies a faint band, which is the outermost visible part. Finally, outside of this band, there are the invisible ultraviolet rays, which probably extend quite a bit further, up to 350-300 μμ, but whose extent and numerical ratio I have not been able to determine

The effect of these two faint bands, as well as the (unmeasured) ultraviolet rays, is discovered by comparing the effect of light that has passed through distilled water with the effect of light that has passed through quinine sulfate. Part of the difference may be due to the admittedly insignificant weakening of the band lying between 426 and 418 μμ upon passage through the quinine sulfate solution.

Despite the faintness of the light and the small extent of the two outermost bands and the strong absorption of ultraviolet rays by the glass, this outermost part of the spectrum has a powerful inhibitory influence on the growth of bacteria. How much of the effect is due to the two violet bands mentioned and how much to the ultraviolet rays cannot be determined.

without knowing the extent and ratio of these rays, or one would have to be able to use a substance as a light filter that would destroy them without taking some of the visible rays with it. However, to my knowledge, such a substance does not exist

Incidentally, I would like to point out that the range of ultraviolet rays cannot be precisely defined; there are individual differences in the ability of the eyes to perceive the extreme violet rays, and the ability of these rays to make an impression on vision varies depending on the type of light source, since this, like any other light impression, depends on the quantitative ratio of the rays. Sunlight, for example, can only be seen in the spectroscope I use up to Frauenhofer's line H_2 (393 μμ); at approximately the same point, the dark band in the spectrum of electric arc light begins; the bright band, which extends further out, between 388 and 385 μμ, thus corresponds in wavelength to the invisible ultraviolet rays in sunlight. The fact that these rays are only visible in the spectrum of electric light is due to

1) Widmark has demonstrated that the limit for the outermost visible violet in electric arc light shows the following significant individual oscillations, but does not vary significantly according to age groups under 50-55 years:

Maxim. Minim. At

ages 11-20 years: 378-395 μμ on average 386 μμ " 21-30 31-40

— ,, 371-395 ,, 380.5-394.5; 382.5" ,, — gränsen

,, 13 382.91 388.7 " ,, — för det

,, ,, 372.5-393 11 — WIDMARK: Om — synliga

spektrum. [On the limit for the visible spectrum]. Öfversigt af Kongl. Vetenskaps-Akademiens Förhandlingar 12. Maj 1897, No. 5, p. 287.)

It is in good agreement with these studies that Candidate Larsen and I, both of whom are between 21 and 30 years old, could see down to approximately 385 μμ. Neither of us was familiar with Widmark's studies at the time

probably because more rays are concentrated at this point in electric light than in sunlight.

When assessing the effect of ultraviolet rays, one must also take into account that the light has passed through thick layers of glass, which absorbs all rays with a wavelength shorter than 350-300 μμ that may be present in the arc light. However, one is able to investigate the effect of concentrated light, which contains rays of even shorter wavelength, by collecting the light with rock crystal lenses instead of glass; because rock crystal allows rays with a wavelength of up to 200 μμ to pass through. However, the institute did not yet have collecting apparatus with rock crystal lenses when these experiments were carried out, and so I had to postpone an exact determination of the effect of this spectral region until another opportunity

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So far, I have calculated exclusively based on the time it takes for the light to weaken the growth of the bacteria. From Table 1, it is easy to see that the relationship between the effect of the various sections of the spectrum changes somewhat when calculated based on the time it takes for the light to kill the bacteria, although the main thing: the predominant influence of the blue, violet, and ultraviolet rays remains unchanged. I cannot say why this is the case; there are several possibilities that cannot be overlooked on the basis of the present investigations. 1)

1) It is certainly largely due to the different bactericidal powers of the marginal rays and the central rays of the light cone, as I was able to detect the slightest weakening of the bacteria when the number appeared in the center of the illuminated spot; in contrast, I only considered the bacteria to be killed if they were also killed at the edge of the illuminated part. (Compare p. 63).

The entire relationship to the bactericidal effect is easily understood from the considerations presented above.

Summary.

1. All rays of the spectrum, except the ultra-red, which have not been investigated, from the red upwards, inhibit the development of bacteria. Whether the red rays are capable of killing bacteria has not been directly proven; all the other parts of the spectrum have the ability to do so.

2. The effect increases with the refractive index.

3. The effect is mainly due to the blue, violet, and ultraviolet rays.

4. These results apply to Bacillus prodigiosus and to the specific light I used (the light of an electric arc lamp of 35 amps and 46-44 volts, concentrated by the Finsen light-collecting apparatus described).

V.

On the Power of Light to Kill Shoot and Mold Fungi

by

Valdemar Bie.

Knowledge of the effect of light on shoot and mold fungi has been very limited until very recently; it was usually assumed that it had the same effect on these organisms as on other plants. I will give some results of earlier investigations below.

De Bary (1863) discovered no effect of light on the growth of Peronospora species; on the other hand, he found a favorable effect on the development of Uromyces appendiculatus. When he sowed his spores on bean leaves that were illuminated from only one side, they grew first on the illuminated side.

Van Tieghem (1881) demonstrated the same thing with Penicillium glaucum; in a bottle with spore-containing oil,

DE BARY: Research on the development of some parasitic mushrooms. Annales des sciences naturelles, p. IV, Botanique, vol. 20, 1863, pp. 54 and 98.

VAN TIEGHEM: Action of light on the vegetation of Penicillium glaucum in oil. Bulletin of the French Botanical Society, 1881, p. 186.

This fungus in such a way that its contour formed a regular curve, the apex of which corresponded to the middle of the side of the bottle facing the light; on the opposite side, the mycelium did not develop at all or almost not at all. If porous, moist, burnt clay was placed in a bottle containing spore-containing oil, the fungus also grew only on the sides of the clay facing the light.

Van Tieghem (1884) and Winter (1874) are even of the opinion that light is necessary for the development of the mycelium of Pyronema confluens and Peziza Fuckeliana de By.

Kny (1884) discovered no influence of light on the rate of reproduction in Saccharomyces cerevisiae.

None of these authors has proven that light is capable of killing budding and mold fungi

Zopf was therefore quite right to note the following in 1890: "Direct sunlight appears to have a slightly fatal effect on the thallus of most saprophytic molds and basidiomycetes, evidently due to the rapid drying it causes. Whether sunlight itself can also have a fatal effect, similar to that of certain schizophytes, remains to be investigated."

Zopf seems to have overlooked one study here, namely that of Downes and Blunt from 1878 and 1879.

Van Tieghem: Culture et développement du Pyronema confluens. Bulletin de la Société botanique de France 1884 p. 356

WINTER: Heliotropism in Peziza Fuckeliana de By. Bot. Zeitung 1874 p. 5. Ref., after F. Elfving: Studies on the Effect of Light on Fungi. Helsingfors 1890 p. 13.

KNY: The Relationship of Light to Cell Division in Saccharomyces cerevisiae. Berichte d. deutschen botan. Gesellsch. II 1884 p. 129. Ref. after Elfving 1 c. p. 15.

ZOPF: The Fungi in Morphological, Physiological, Biological, and Systematic Relationships. Breslau 1890 p. 219. Ref. after Elfving.

DOWNES and BLUNT: Researches on the Effect of Light upon Bacteria

These authors, the originators of the theory of the ability of light to kill microorganisms, have subjected all related questions to excellent, thorough investigation. They made the observation that when unboiled pasteurizer liquid was illuminated, fungi never grew in it during this procedure, even when placed in the dark after a longer illumination; but if the liquid was placed in the dark or in diffused daylight after a shorter illumination period, fungi grew in several cases, but no bacteria.

From this, Downes and Blunt conclude that light delays or even prevents the development of those microscopic fungi that are involved in putrefaction and decay, but that it has a lesser effect on these organisms than on bacteria.

In recent years, numerous investigations have been carried out, but they have not produced any reliable results

Gaillard investigated Oidium albicans and red yeast (levure rouge) by sowing them in flasks of broth and placing the flasks in sunlight during the day and in an icebox at night.

Oidium was not affected by this; individual cultures even grew during the illumination. On solid food substrates, no clear difference could be detected, regardless of whether the culture was in a light or a dark place.

The red yeast also grew during the illumination;

and other Organisms. Proceedings of the Royal Society of London vol. 26, 1878 p. 488.

Downes and Blunt: On the Influence of Light upon Protoplasm. Proceedings of the Royal Society of London v. 28, 1879 p. 199

G. Gaillard: On the influence of light on microorganisms. Thesis. Lyon 1888.

One of the cultures even seemed to have grown much more than those that had been kept in a dark thermostat for control.

On solid food substrates, colonies always appeared clearer and thicker in direct or diffuse sunlight than in the dark.

According to Gaillard's investigations, sunlight therefore favors the development of the two species mentioned

Laurent exposed spores of Ustilago carbo in glass flasks to direct sunlight. After 8 hours of illumination in July, the spores had died, while those serving as a control developed normally. These spores were far more easily influenced than the spores of Aspergillus niger and glaucus, Botrytis cinerea, and Cladosporium herbarum. Spores of Penicillium and Cladosporium were also killed by the light, the former more easily than the latter

Elfving discovered that intense summer sunlight prevented the spores of Aspergillus glaucus from germinating, but did not kill them, even after 8 days of exposure. The fungus was easily destroyed by the light after germination in the first stages of development; fully grown mycelium, on the other hand, could be exposed to sunlight for several days without dying. The spores behaved in the same way: those that had just formed were killed by sunlight in one day; the mature ones could be insolated for several weeks without damage.

Martinaud tested the ability of light to sac-

Laurent: Influence of light on the spores of charcoal des cereales. Comptes-rendus Soc. roy. de Botanique de Belgique, vol. 28, 1889, p. 162. Ref. after Elfving, 1 c. p. 19

F. ELFVING: Studies on the Effect of Light on Fungi. Helsinki 1890 p. 105.

MARTINAUD: Influence of solar rays on fungi, which the Finnish

to kill Saccharomyces apiculatus and Saccharomyces ellipsoideus I and II by illuminating either freshly picked grapes immersed in sterile water in which he had suspended shoot cells, or a sterile glass plate or paper treated in the same way. After illumination, an experiment was carried out to see whether the germs grew in sterile wine must.

It was found that the germs were killed at 41-45° C after illumination for 4 hours, and at a lower temperature only after longer illumination.

Marshall Ward used the method described in my previous paper

He demonstrated microbicidal activity on the following species: Oidium lactis, Chalara mycoderma, Saccharomyces pyriformis, and Stysanus. The following species, however, gave a negative result: Aspergillus glaucus, Penicillium crustaceum, Mucor racemosus, Nectria cinnabarina, and Botrytis cinerea.

Marshall Ward points out that all the species that gave a positive result have hyaline, colorless, or very pale yellowish spores, whereas all the species that were not affected have clearly pigmented spores.

I will not go into a detailed criticism of the method of investigation used by the authors cited, since it would essentially be a repetition of what I have already stated in my previous treatise. However, I must contre à la surface des raisins. Comptes rendus de

l'Académie des sciences t. 113, 1891 p. 782

H. MARSHALL WARD: Further Experiments on the Action of Light on Bacillus anthracis. Proceedings of the Royal Society of London, vol. 53, 1893, p. 23.

Again, point out that the main error in previous experiments of this kind was the use of too weak light and the lack of light measurements

It goes without saying that one must use light of a certain intensity to produce a clear difference between the growth of fungi in the light or in the dark. It is no less necessary to measure the light intensity. One cannot speak of light in general, nor of heat; just as it follows naturally that one measures the temperature in experiments with the bactericidal effect of heat, one must also, of course, state the intensity of light in experiments of the same type with light. If this is not done, it is impossible to assess the value of the experiments later, among other things because it is not certain that the microorganisms react the same to all intensities or types of light.

I emphasize this because I realize that in experiments with the strongest light available to me, the influence of light on the growth conditions of the microorganisms in question was not exhausted; it will undoubtedly also be of interest to test the effect of weaker light

---

The procedure in my experiments was essentially the same as that described on pages 60 and 61, except that I took into account a result of my earlier experiments, namely the strong effect of ultraviolet rays. In order to utilize this as much as possible, the concentrating apparatus with glass lenses described on page 61 was replaced by one with rock crystal lenses, which allow far more ultraviolet rays (see page 76) to pass through

and instead of culture flasks, I used dishes made from a rock crystal plate mounted in a brass ring. Incidentally, no essential changes have been made to the construction of the concentration apparatus. It consists, like the one described earlier, of two sets of lenses mounted in a brass tube. Next to the light are two lenses, 6.5 cm in diameter and 30 and 20 cm focal lengths, respectively, mounted at a distance of 12 cm from the lamp, which collect the divergent rays radiating from it into parallel ones. At the opposite end of the brass tube, two lenses are mounted, which collect the parallel light rays into convergent ones and enclose a 30 cm thick layer of distilled water, which cools the light by absorbing the ultra-red rays

The electric lamp burned at 45 amps and 50-45 volts (approximately 10,000 standard lights).

I prepared the cultures by scraping off some of a surface culture, suspending it in wort, filtering it through hygroscopic cotton, and mixing the filtrate with wort agar, which was then evenly distributed in the dishes. However, I could not scrape any of the Aspergillus niger culture and therefore had to make the suspension by shaking the culture with wort, after which I filtered. During illumination, the dishes were placed outside the focal point of the concentrating apparatus at the point where the light cone had a diameter of 4 cm

After the illumination was finished, the dishes were placed in the dark and converted into humid chambers by placing them on moist filter paper with the bottom facing up. I believe I have avoided confusing the effect of light with the effect of heat. I

applied the same precautionary measure as in the previous series of experiments: sprinkling with cold water. Furthermore, I mounted the dish in a clamp without a background; although the light is very warm, under these conditions it passes through the culture without absorbing many heat rays. I have convinced myself through control experiments that a 10% gelatin, whose melting point is approximately 27°C, does not melt by the method used, even when illuminated without sprinkling

reliable investigations by Marshall Ward — The most detailed and been carried out to date, as reported on p. 82, — that have give the result that not all mold and fungal species are killed by direct sunlight. Whether this was due to the light being too weak or to the fact that some species are not actually harmfully affected by the light cannot be judged, especially since the intensity of the sunlight was not measured. In such doubtful cases, the advantage of using concentrated light of such intensity becomes apparent: one can conclude that it is capable of producing a positive reaction in all cases where one can be produced at all. By applying such a light, I have demonstrated that in every case the few species I have examined are inhibited in growth and killed with sufficiently long exposure.

—

I have tested 1. Saccharomyces apiculatus, 2. Monilia candida, 3. a red-pigmented Torula species, 4. a Cladosporium species, 1)

1) Prof. Dr. phil. Emil Chr. Hansen, Director of the Physiological Department of the Carlsberg Laboratory, has shown me the kindness to identify this species by microscopic examination

which forms brownish-black pigment, and 5. Aspergillus niger examined.

Regarding these 5 species, my experimental journal contains the following:

1. Saccharomyces apiculatus.

1.3 killed when illuminated for 30 . . . . minutes.
1.9/3 20 " " . . . . "
2.9/3 15 " " . . . . "
1.4/10 " " . . . . "
20/4 5 " " . . . . "
2.2/4 5 " " . . . . "
4 " " . . . . not killed.
3 " " . . . . " "
2.3/4 " " . . . . : 5 killed.
4 " " . . . . "
2.2/4 5 " . . . . "
. . . . 4.2, " not killed?
" " . . . . 4 not killed.
3 " " . . . . " "

2. Monilia candida.

1.9/3 killed when illuminated for 30 . . . minutes.
2.3/15 " " . . . "
1.4/4 " " . . . 5 almost killed.
10 " " . . . killed.
2.4/20 10 " " . . . "
2.2/4 5 " . . . "
2.3/4 5 " " . . . "
4 " " . . . not completely killed.

3. A Torula species

1/2 illuminated for 30 minutes, ... killed.
" " . . . . 20 not killed.

illuminated for 20 minutes . . . . not killed. 7/3
12/3 30 " " . . . . killed.
25 " " . . . . not killed. 29/3

4. A Cladosporium species.

24/2 illuminated for 30 minutes . . . . killed.
5/3 15 " " . . . . not killed.
7/3 20 " " . . . . " "
10/3 25 " " . . . . " "
12/3 30 " " . . . . killed.

5. Aspergillus niger.

31/ illuminated for 60 minutes, . . . not killed.
20/4 90 " " . . . killed.
29/4 90 " " . . . "
2/5 75 " " . . . not completely killed.
9/5 60 " . . . not killed. "

The fact that a repetition of the experiments always produced the same result, with the exception of two cases (Saccharomyces apiculatus 2.3/4, 4 minutes, and Monilia candida 1.4/4, 5 minutes), seems to me to speak for the accuracy of the test method.

From the experimental journal, one can see that

Saccharomyces apiculatus is killed after 5 minutes, but not after 4 minutes.
Monilia candida 5 and 4 " " " " "
Torula " 30 " " " " 25 "
Cladosporium 30, 25 " " " " " "
Aspergillus niger 90, " " " " "
75.

An illumination time lying between the two times given is the exact expression for the time in which the light kills the species in question under these conditions.

For comparison, it is stated that Bacillus prodigiosus is killed after approximately 1 minute under the same conditions

and is evidently weakened by illumination of 1/2-1 second.

From my experiments it is clearly evident

1. that the species of fungi and molds examined can all be killed by a sufficiently strong light,

2. that their resistance to light is much greater than that of Bacillus prodigiosus (and the other bacteria examined at the Light Institute, see p. 93), as well as

3. that the resistance is significantly greater in the pigment-forming species (Torula, Cladosporium, and Aspergillus niger) than in the non-pigmented ones (Saccharomyces apiculatus and Monilia candida).

VI.

Do the different species of bacteria have the same resistance to light?

Axel L. Larsen.

In order to investigate whether individual bacterial species have different resistances to the killing effects of light, it is best to use a constant light. If an inconstant light is used, such as sunlight, one can, of course, expose cultures of different bacterial species simultaneously and under the same conditions. However, in this way one can only conduct a qualitative investigation into whether there is a difference in the resistance of the individual bacterial species, as well as form a reasonable idea of the magnitude of this difference.

By frequently measuring the light intensity, one achieves some certainty, but this is not complete, since there is no actinometer that reacts exactly like bacteria.

For example, if two species are illuminated simultaneously, one dies after 6 hours of illumination, the other after 8 hours

killed, one can only conclude that they have different resistance; the last 2 hours of illumination cannot be compared with any of the periods of the previous 6 hours.

If one wants to be precisely informed about the conditions, one must conduct a quantitative investigation using constant artificial light.

Of the researchers who previously investigated the bactericidal effect of light, very few worked with constant artificial light, and none of them dealt with the conditions discussed here. And of those who used the sun as a light source, only Buchner illuminated cultures of different species simultaneously, namely Bacillus tyfosus, B. coli communis, and B. pyocyaneus; he found no clear difference between their resistance. A few others have investigated different species at different times; from this, as can be seen from the above considerations, no conclusions at all can be drawn

Therefore, highly accurate, comparative investigations into the effect of light on various bacteria are needed, and I conducted precisely such investigations. For the time being, I have only examined a few species, as I selected them from the large group of bacteria; however, I hope to be able to publish experiments with a larger number of species later.

I have set up my experimental technique in such a way that I can compare experiments carried out at different times. First, as far as the light source is concerned, I used an electric arc light. The lamp I used during the experiments ranged from 35 amps and 46 to

44 volts, and the current intensity was controlled by an ammeter. I always used the same carbons to produce the light

The light was concentrated using a collecting apparatus of an older design by Professor Finsen. I used this apparatus for all investigations, so that the amount of light was always the same.

To further check this point, I frequently attempted to determine how much time was needed to kill and weaken Microc. prodigiosus, and each time this time was constant, namely 35 minutes and 15 seconds, respectively.

After these explanations, I can consider it proven that the light intensity was always the same. The bacteria were sown from broth cultures into liquid agar, which I allowed to stiffen in a thin layer on one of the inner sides of a small rectangular bottle.

The same amount of agar was used for each experiment, namely 2 cc, and the bacteria were distributed as evenly as possible

Seeding in the liquid agar was carried out when it had a temperature that was not detrimental to the bacterial species under investigation. A number was drawn on the outside of the flask with asphalt varnish, which, when the flask was illuminated, shaded part of the bacteria. To prevent the influence of heat, the illuminated part of the flask was continuously sprinkled with cold water for the duration of the experiment.

The technique is therefore the same as that used by Finsen. By pouring a certain amount of agar onto one side of the flask (the flasks are all the same size),

1) N. R. Finsen: On the Application of Concentrated Chemical Light Rays in Medicine. Leipzig 1899, p. 19 (Vogels Verlag).

This ensures that the light passes through a layer of agar of equal thickness in all experiments. Refraction of light is avoided because the sides of the flask are flat, and the corners and edges of the flask are not illuminated at all, but form part of the unlit section of the flask used for control purposes.

This section, as well as the agar under the black number, has the same effect here as the control tubes in the investigations of the earlier authors and is more reliable, since it shows that the cultures are viable precisely in the illuminated flask.

It goes without saying that the flask was placed in such a way that the light fell at a right angle onto the illuminated part of it.

I considered the criterion for the bacteria being killed to be the fact that the illuminated part of the agar remained sterile, even after the flask had stood in a thermostat at a temperature favorable for bacterial culture, until the culture in the unlit part had grown strongly

Before I proceed to describe my experiments, I will briefly explain the terms used in the tables. On one side of which are listed the experiments intended to determine how much time the light needs to kill the bacterial species under investigation, while on the other side it is stated how long the light must act on to weaken its growth.

By "action," I understand the inhibition of the growth of the bacteria, visible to the naked eye, after they are illuminated. The action is called "just visible" when, after a certain time, the bacteria located under the black number in the shadow have grown a little more than the illuminated ones, so that the

The difference can only be discovered by very close inspection. With the term "visible exposure," this difference is somewhat greater, but by no means noticeable, which is the case when the exposure is described as "distinct." "Strong exposure" indicates that some of the sown bacteria have been killed, but that numerous others are still growing. "Very strong exposure" means that most of the bacteria have been killed; if the exposure is described as "killed," this means that none of the illuminated bacteria have grown at all after the culture flask has been in the thermostat.

Furthermore, I would like to point out that when it is necessary to investigate how much time the light needs to inhibit the growth of the bacteria, one must sow densely and check the culture frequently, since the difference between the illuminated and unilluminated sections can only be noticed when the growth has reached a certain intensity—a circumstance that, of course, gradually evens out

The following species were examined: Bacillus pyocyaneus, cyanogenus, Typhi muris, Typhi, Bacillus coli commune, as well as Staphylococcus pyogenes albus, aureus, and citreus.

1.

Bacillus pyocyaneus.

Number of trials	Illumination time in min.	Exposure	Number of trials	Illumination time in sec.	Exposure
1	20	Severely killed	2	5	None
4	25		4	10	Visible
			5	20	
			2	30	Clearly

II.

Bacillus cyanogenus.

Number of trials	Illumination time in min.	Exposure	Number of trials	Illumination time in sec.	Exposure
1	20	Strongly	2	5	None
4	25	Killed	6	10	Barely visible
			6	15	Clearly

III.

Bacillus typhi muris.

Number of trials	Illumination time in min.	Exposure	Number of trials	Illumination time in sec.	Exposure
1	30	Strong	2	5	None
1	40	Strong	2	10	Visible
1	45	Very strong	2	20	Visible
4	60	Killed	1	30	Clearly

IV.

Bacillus typhi.

Number of trials	Illumination time in min.	Exposure	Number of trials	Illumination time in sec.	Exposure
2	30	Strongly	3	5	None
3	45	Killed	3	10	Visible Visible
			3	15	

V.

Bacterium coli commune.

Number of trials	Illumination time in min.	Exposure	Number of trials	Illumination time in sec.	Exposure
2	30	Strongly	4	10	None
4	35	Strong	4	20	None
2	40	Very strongly	4	25	None
4	45	Killed	4	30	Barely visible
			4	40	Visible

VI.

Staphylococcus pyogenes aureus.

Number of trials	Illumination time in min.	Exposure	Number of trials	Illumination time in sec.	Exposure
3	30	Strongly	2	5	None
5	35	Killed	2	10	Just visible
			6	20	Visible
			6	30	Clearly

VII.

Staphylococcus pyogenes albus.

Number of trials	Illumination time in min.	Exposure	Number of trials	Illumination time in sec.	Exposure
1	30	Strongly	2	10	None
3	35	Killed	3	20	Visible Visible
			3	30	Clearly
			5	40	

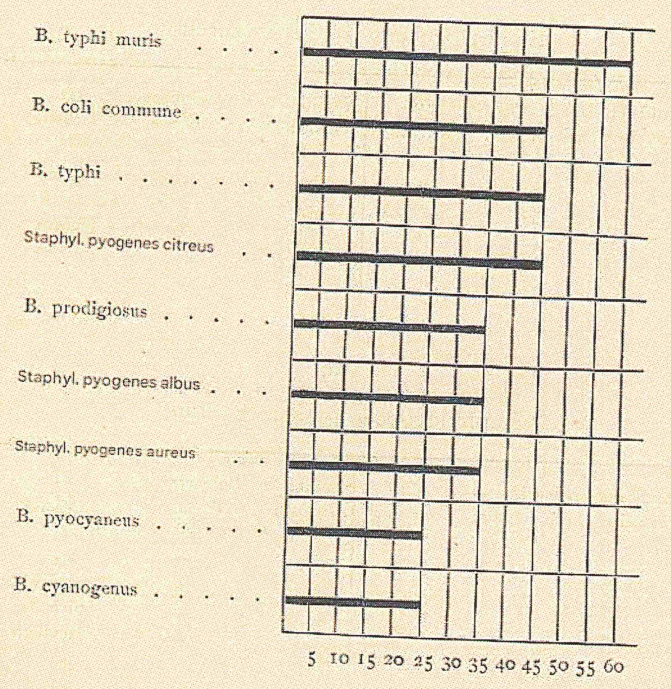
VIII.

Staphylococcus pyogenes citreus.

Number of experiments	Illumination time in min.	Exposure	Number of experiments	Illumination time in sec.	Exposure
	30	Strong	4	20	None
	35	Strong	4	30	None
	43	Very strong	4	50	None
3	45	Killed	4	55	Visible

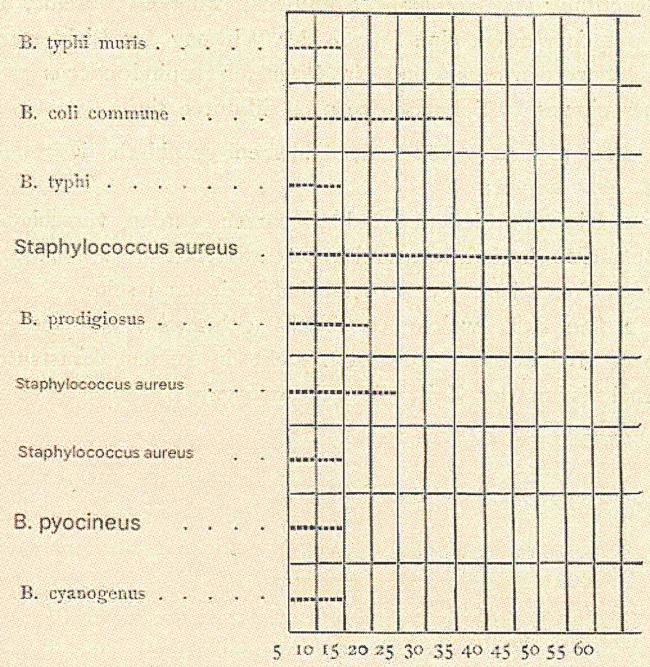
From the above-mentioned experiments, which, as stated, are only a part of a longer series of investigations on

Killed. The time is given in minutes.



this question, it is clear that just because a single species is killed by the light in a certain time, one cannot conclude that all bacteria behave in the same way. For the time necessary to kill the species I examined varies from 25 minutes to 1 hour,

Weakened. The time is given in seconds.



thus, up to more than double. Nor can one conclude that if one species of a particular bacterial form is killed in a certain time, then the other species of the same morphological group will behave similarly; e.g., one sees that Staphylococcus pyogenes albus and aureus are killed after 35 minutes, while Staphylococcus citreus must be illuminated for 45 minutes.

The time necessary to weaken the growth of bacteria in general also varies somewhat according to my experiments, fluctuating between 5 and 55 seconds, and is not proportional to the time necessary for destruction for the species examined. For example, weakening is detected in Bacteria typhi muris after just 10 seconds of illumination, while in order to be killed, it must be exposed to the light for one hour, and the times for Staphylococcus pyoogenes citreus are 55 seconds and 45 minutes, respectively.

From my experiments, which are graphically presented above, it can be seen:

1. The different species of bacteria are affected differently by light, and even between very closely related species, the difference can be significant

2. The time it takes for light to kill a given species of bacteria is not in a constant relationship to the time it takes to weaken it.

VII.

On the intensity of the sun's rays by Dr. Absalon Larsen.

If the intensity of the sun's rays outside the atmosphere is given, the intensity of the rays reaching the surface depends only on the altitude of the sun and the state of the atmosphere

As early as 1760, Bouguer formulated the theorem that the sun's rays are weakened according to a geometric progression if the air mass traversed by them increases according to an arithmetic progression. For example, if the intensity of the rays outside the atmosphere is I and the intensity of the part of the rays reaching the Earth's surface at vertical incidence is a I, then according to Bouguer, the radiation intensity at the Earth's surface can generally be set equal to anI, where the traversed air mass means the air mass at vertical incidence taken as unity.

In 1838, Pouillet published his work on solar radiation. With the help of the pyrheliometer, he determined the radiation intensity at different altitudes above the sun and, using Bouguer's formula, came to the conclusion that the amount of heat which, at vertical

The amount of radiation supplied by the sun's rays outside the atmosphere in 1 minute at right angles to a 1 square centimeter, absolutely black surface, is the so-called solar constant, and the transmittance coefficient a is equal to 4/5.

During the years 1874-79, Viole undertook numerous experiments on solar radiation using an improved apparatus, the actinometer, whose heat-sensitive part consisted of a blackened thermometer vessel. To protect against air currents and to allow greater regularity of radiation, the vessel was surrounded by a double-walled sphere, the cavity between the two spherical shells of which water flowed. An opening on one side allowed the rays to reach the thermometer. Viole gives the value of 2.54 calories for the solar constant

In his great work, 1) Langley points out that Bouguer's formula is only valid for individual types of rays, and that when applied to all radiation, the solar constant must always be too small.

Langley's work on solar rays must still be considered the most important in this field. Using a rock-salt prism and concave mirror, or in other cases with a Rowland grating, he resolved the rays into their individual components and, with the bolometer he invented for this purpose, measured the heat effect of the various types of rays, from rays of wavelength 0.35 (ultraviolet) to rays of wavelength 14.0 (ultrared), and later even further into the ultrared to rays of wavelength 34.0, the existence of which was first postulated by Langley.

1) Researches on solar heat and its absorption by the earth's atmosphere. A report of the Mount Whitney expedition. Washington 1884

was demonstrated. By comparing the energy spectra of the sun's rays obtained in this way at different altitudes above the sun, it was found that the transmission coefficient varies greatly with wavelength, in such a way that the violet rays are attenuated the most and the red rays the least when passing through the atmosphere. The following table lists the transmission coefficients found by Langley in Alleghany in the years 1880-81:

Wavelength:	0.375	0.400	0.450	0.500	0.600	0.700	0.800	0.900	0.00
Transmission Coefficient:	0.39	0.42	0.48	0.54	0.64	0.71	0.76	0.79	0.80

From this table, for example, it can be seen that of certain ultraviolet rays, with perpendicular incidence, only 39 percent reach the Earth, whereas under the same conditions about 70 percent of the red rays and about 80 percent of certain ultrared rays reach the Earth.

After Langley had arrived at these important results, he undertook a scientific expedition to Mount Whitney, a mountain in the Sierra Nevada, where, assisted by numerous collaborators, he collected a wealth of observational material in August and September 1881, partly at the foot of the mountain 3,700 feet above sea level and partly on a lofty peak 11,600 feet above sea level. This material he processed after his return to Allegany and supplemented with additional experiments

Regarding the hike from the station at the foot of the mountain (Leon Pine) to the summit, Langley writes that even without any use of instruments, the change in light was easily noticeable. The color of the sky appeared far more dark blue and violet. And the skin of the face

and the hands were severely attacked by the rays, although the air was cold and the skin had long been exposed to the burning sun's rays at the low station. 1)

Some numerical values of the experimental results are reported in the following table according to Langley. The

Place of observation	At the foot of the mountain			At the summit			
Altitude above sea level	3760 feet			11625 feet			
Barometer reading	662 mm			499 mm			
Air mass	717	1414	2152	572	746	1128	2300
Wavelength = 4.350	25.1	10.0	0.0	39.0	14.8	16.3	5.1
— 0.375	28.4	15.7	4.0	4.3s	23.2	20.3	12.8
— 0.400	50.1	29.6	12.4	71.5	68.0	42.1	35.3
— 0.450	110.6	88.3	71.1	174-2	162.5	149.3	118.5
— 0.500	153.9	129.5	117.6	229.0	214.4	203.2	160.0
— 0.600	201.0	177.0	160.7	249.7	240.4	228.1	183.5
— 0.700	191.1	180.7	162.5	214.8	218.3	204.6	176.1
— 0.800	155.5	151.7	134.3	159.4	165.3	157.9	136.9
— 1.000	100.2	94.6	82.1	100.4	100.4	94.7	81.1
— 1.200	76.4	58.5	51.4	72.1	69.1	60.0	49.1
— 1.400	58.0	44.4	38.8	56.1	50.5	43.8	32.7
— 1.600	42.5	32.7	28.6	42.7	37.8	33.1	24.1
— 1,800	29.6	22.9	20.0	30.8	27.5	23.8	17.2
— 2,000	18.3	14.7	12.0	20.4	18.7	15.8	11.4
— 2,200	10.1	7.9	6.9	11.4	10.5	9.0	6.5
— 2,400	3.2	2.5	2.2	3.8	3.6	3.2	2.6
Total heat in relative mass 75-00	64-85	56.96	83-85	80.67	74-15	60.51	

Columns indicate the heat effect of the various types of rays, i.e., the energy distribution in the spectrum. The different columns correspond to the various external

envy

1) Compare with this the experiments of Prof. Finsen on the effect of ultraviolet rays. This booklet page 8.

circumstances, the altitude above sea level, and the path traveled by the rays through the air, which is given as the air mass. For example, "air mass 717" means that the column of air irradiated by a beam of rays has the weight of a column of mercury of the same thickness and 717 mm in length

Let us first consider the numbers in the first and third columns. The former indicate the intensity of the rays after passing through an air mass of 717, which, at a barometer reading of 662, corresponds to a high solar altitude. The latter show the intensity of the rays after passing through three times the air mass, i.e., at a low solar altitude.

All rays have been weakened by the increased air mass, but to very different degrees. The ultraviolet rays of wavelength 0.35 µm have been completely absorbed. The violet rays of wavelength 0.375 µm have been reduced from 28.4 to 4.0 µm, i.e., to approximately 17%, the blue rays of wavelength 0.40 to 1/4, and the red rays of wavelength 0.7 to 4%. The numbers in the last four columns, relating to the observations at the summit, show a very similar behavior The ultraviolet and violet rays have been attenuated the most, the red and ultrared the least; but the decrease in intensity is smaller at the summit than at the foot of the mountain for the same increase in air mass. This shows that a given mass of air in the upper part of the atmosphere exerts less absorption than an equal mass of air in the lower part of the atmosphere. This difference is particularly considerable for rays of short wavelength.

According to what has been said, sunlight is not only attenuated as a whole by the absorption of the atmosphere, but its composition is also changed. Langley compares the sun seen through the atmosphere with that seen through

Electric light seen through a red-yellow glass. Someone who had seen only such light in his entire life would call it white light. But if, after removing the glass, the electric light shone in its full glory, it would appear blue to him, just as the sun appears to us if we could observe it from a point outside the atmosphere...

The higher the sun is in the sky and the higher one rises above sea level, the more powerfully the blue and violet sunrays will emerge, all other things being equal.

Langley's investigations were carried out under the most favorable atmospheric conditions possible. The air was perfectly clear, the sky cloudless. Only exceptionally would one find equally clear days here. Langley calculates the solar constant from his experiments and arrives at an even greater value than Violle, namely 3 cal

In Europe, Crova has been conducting investigations into solar radiation in Montpellier for several years. His curves, recorded with a self-recording apparatus, are of particular interest, as they clearly represent the solar radiation that actually reaches the Earth's surface at any time of day and on any day of the year. The heat-sensitive part of the apparatus consists of a thermocouple, one soldering point of which lies in the shade, while the other is exposed to the rays and is always directed towards the sun by means of a heliostat.

Figs. 1 and 2 show two curves recorded by Crova simultaneously in Montpellier and on Mont Ventoux.

-1971) Mémoires de l'Académie de Montpellier. October 10, 1884.
Donab Annales de Chimie et de Physique. (6) October 14, 1888 and February 21, 1890.

reproduced. The two curves show a depression at noon, and as can be seen, the noon ordinate divides the curves asymmetrically. This probably stems from the changing water vapor content of the atmosphere. The many quite considerable rapid fluctuations in the intensity of solar radiation are more pronounced at the low station than on the mountain. The weather was perfectly clear at both locations. Crova therefore believes that these fluctuations are due to movements of water vapor in the atmosphere. They are more pronounced in summer and on warm, calm days than in winter and on days with a fresh wind.

In Kiev (Russia), Savelief obtained very similar curves. 1)

Recently, K. Ångström has undertaken absolute measurements of solar radiation using new apparatus 2). No report has yet been given on the results.

While only those investigations relating to the heating effect of the sun's rays have been mentioned above, a number of other works exist on the chemical effects of the rays

Bunsen and Roscoe worked with a hydrogen chloride photometer. A mixture of equal parts of chlorine and hydrogen was sealed above water in a glass vessel. Under the influence of the sun's rays, hydrogen chloride was formed, which was absorbed by the water. This caused a reduction in the gas volume, which could be read off in a narrow tube. The reduction in the gas volume was taken as a measure of the chemical energy released by the rays. The results of Bunsen and Roscoe's measurements, as well as a detailed description,

1) Comptes rend. de l'Acad. des Sciences. CX, page 235. 1890.
2) Annalen der Physik und Chemie 67, page 633. 1899

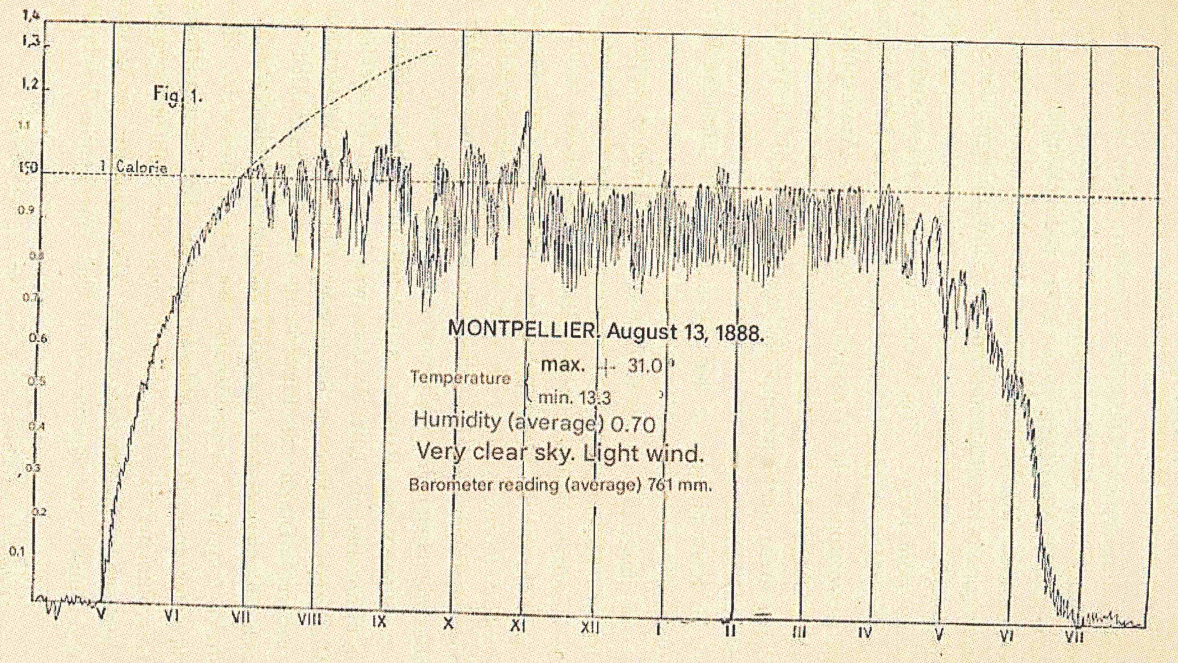


Fig. 1.
1 Calorie
MONTPELLIER. August 13, 1888.
Temperature
max. + 31.0°
min. 13.3
Humidity (average) 0.70
Very clear sky. Light wind.
Barometer reading (average) 761 mm.
V VI VII VIII IX X XI XII I II III IV V VI VII

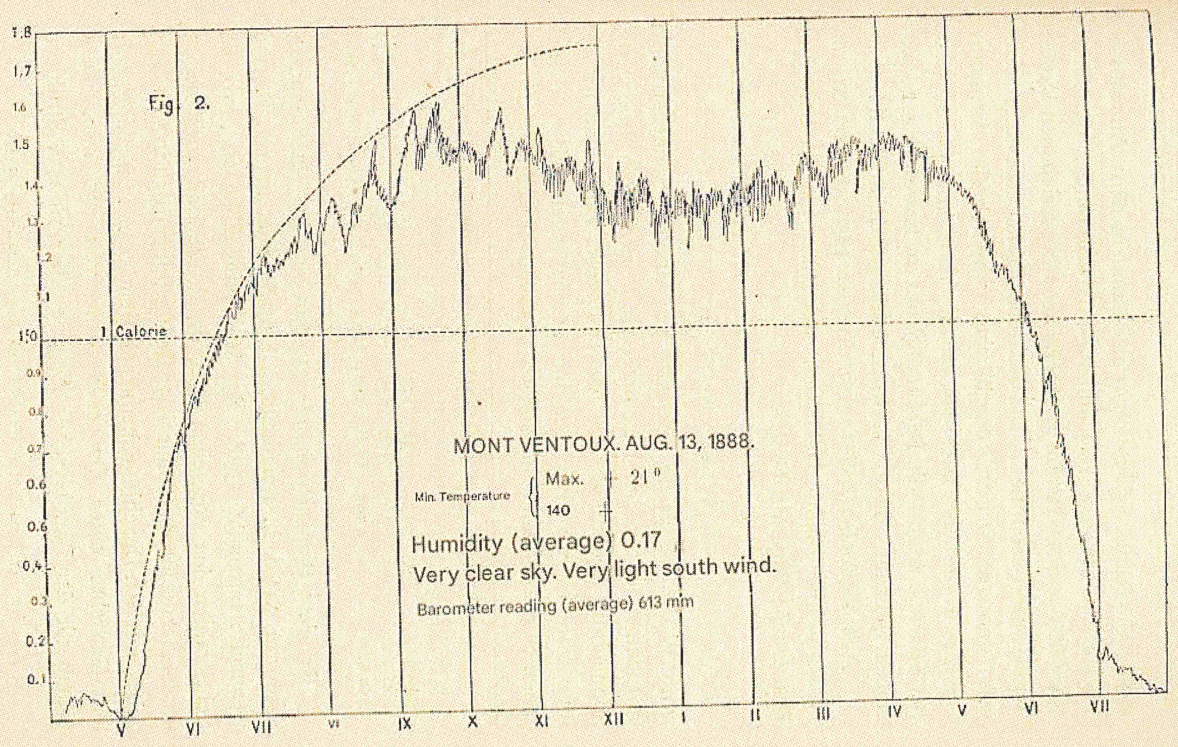


Fig. 2.
1 Calorie
MONT VENTOUX. AUG. 13, 1888.
Min. Temperature
Max. + 21°
140
Humidity (average) 0.17
Very clear sky. Very light south wind.
Barometer reading (average) 613 mm
V VI VII VI IX X XI XII I II III IV V VI VII

The method and conclusions can be found in the "Annals of Physics and Chemistry"[1]). The light from a more precisely described carbon monoxide lamp was taken as the unit of chemical intensity. The carbon monoxide flowed out into the air under very low pressure through a 7 mm wide circular opening. With a gas consumption of 5 cc per second, the exposure at a distance of 1 m was called 1 light unit. 10,000 light units give 1 degree of light.

From experiments carried out on August 3, 1857, and on September 14 and 15, 1858, in Heidelberg, Bunsen calculated the following formula

$$W318.3\ 10 \times \frac{0.4758\ P}{\sin h}$$

where W is the chemical intensity of the direct sun's rays in light degrees, P is the barometer reading in meters, and h is the altitude of the sun. From this formula, the following table can be calculated for the intensity at different barometer readings and different altitudes of the sun.

	90°	80°	70°	60°	50°	40°	30°	20	10°	0°
750 mm	139.8	138.2	132.7	123.2	108.0	88.1	61.5	28.8	2.8	0.0
600 mm	165.0	163.3	158.1	149.0	135.0	114.5	85.3	46.6	7.2	0.0
450 mm	194.4	193.0	188.4	180.1	167.2	147.8	118.8	75.3	18.6	0.0

At a barometer reading of 750 mm and a sun altitude of 90°, i.e., perpendicular incidence, one finds, for example, a chemical intensity of 139.8. At a sun altitude of 300°, where the light rays have to travel twice the distance through the air, the intensity is only 61.5. The quotient 61.5 × 139.8 × 0.44 then gives the transmittance of a layer of air with the weight of a 750 mm column of mercury. This agrees with Langley's statement on violet rays,

1) Annalen der Physik und Chemie 108 pp. 191-273. 1859.

according to which 42% of the rays with a wavelength of 40 penetrate the atmosphere at normal incidence.

Later, Roscoe conducted further experiments on the chemical intensity of the sun's rays. The results, as far as direct sunlight is concerned, largely agree with those already mentioned. But his method is quite different and is based on the effect of the rays on photographic paper. 1)

The blackening of the paper is directly or indirectly compared with suitable standard colors. The method was further developed through the construction of a self-registering apparatus. 2)

Wiesner has also recently worked with photographic paper. In particular, the latter has collected a great deal of material for determining the chemical power of scattered daylight through daily measurements

For the application of direct sunlight in light therapy, it is of practical importance to know both the thermal effect and the chemical effect of the rays at every time of day and year. This can initially only be calculated from the results obtained so far, assuming completely clear weather, and further assuming that the air pressure is constant at 760 mm and that the water vapor content of the atmosphere is the same as in the experiments mentioned. Under these conditions, the following two tables on the thermal effect and the chemical effect of direct sunlight in Copenhagen are calculated: the former from Langley's experiments, the latter from Bunsen's formula.

1) Annalen der Physik und Chemie, Vol. 117, page 529, 1862, and Vol. 128, page 291
2) Annalen der Physik und Chemie, Vol. 151, page 268, 1874. 3) WIESNER: "Investigations into the photochemical climate of Vienna, Cairo, and Buitenzorg (Java)." Vienna 1896

The Warming Effect of Direct Sunrays in Copenhagen.

Time AM / PM	12	11 / 1	10 / 2	9 / 3	8 / 4	7 / 5	6 / 6	5 / 7	4 / 8
December 21	33	31	22	7					
January 20	40	38	31	18					
February 19	55	54	48	39	22				
March 21	65	65	61	55	45	26			
April 21	71	70	68	65	59	48	31	5	
May 21	73	73	71	69	64	57	45	27	4
June 21	74	74	72	70	66	60	50	34	13
July 21	73	73	71	69	64	57	45	27	4
August 21	71	70	68	65	59	48	31	5	
September 22	65	65	61	55	45	26			
October 22	55	54	48	39	22				
November 21	40	38	31	18					
December 21	33	31	22	7					

The Chemical Effect of Direct Sunrays in Copenhagen.

Time AM / PM	12	11 / 1	10 / 2	9 / 3	8 / 4	7 / 5	6 / 6	5 / 7	4 / 8
December 21	4.5	2.5	1.7	0.4					
January 20	12.7	9.9	2.8	1.4	0				
February 19	38.7	34.9	23.8	10.3	1.7	0			
March 21	72.3	68.4	58.3	39.3	18.3	2.1	0		
April 21	100.6	97.6	87.9	71.9	49.6	23.1	2.6	0.3	
May 21	114.6	112.1	104.9	89.8	49.9	44.7	18.7	2.2	0.2
June 21	118.8	116.5	109.9	95.8	76.7	52.6	25.7	5.3	1.6
July 21	114.6	112.1	104.6	89.8	69.9	44.7	18.7	2.2	0.2
August 21	100.6	97.6	87.9	71.9	49.6	23.1	2.6	0.3	
September 22	72.3	68.4	58.3	39.3	18.2	2.1	0		
October 22	38.7	34.9	23.6	10.3	1.7	0			
November 21	12.7	9.9	2.8	1.4	0				
December 21	4.5	2.5	1.7	0.4					

These two tables are not directly comparable, but the pattern of the numbers is. Let us first consider the data in the tables for June. The heat effect is 74 at noon and only drops to about half by 7 a.m. The chemical effect, on the other hand, which is 118.8 at noon, has already dropped to less than half by 5 p.m. and is only 5.3 at 7 a.m., which is 1/20 of the amount at noon. The same difference in change is also noticeable in the two columns for noon in the different months. It follows that for purposes involving the use of the chemical power of the sun's rays while avoiding an overly strong heat effect, only the midday hours and the summer months are favorable. It would certainly be possible to increase the chemical effect through greater concentration even when the sun is low in the sky, but at the same time the heat effect would reach too significant a value

In addition, there is the cloud cover not taken into account above, which precludes regular use of direct sunlight even during the summer months. To get an overview of how many hours per day the sun shines on average in Copenhagen, the table on the next page is calculated from a relevant graphic representation in the monthly report of the Danish Meteorological Institute.

In winter, the sun is uncovered for only a small fraction of the daytime hours. In summer, it shines for an average of one-third of the total daytime hours. In both winter and summer, there are days when the sun shines almost continuously from sunrise to sunset. As a rule, however, it only appears temporarily (for 14 or 1/2 hours), alternating with more or less long periods of shadow

	Number of daylight hours	Average Number of sunshine hours per day			Greatest number of sunshine hours in one day		
		1896	1897	1898	1896	1897	1898
January	7:40 a.m.	0.7	0.5	0.2	5.7	4.1	2.7
February	9:28 a.m.	1.6	2.3	0.9	7.4	7.6	6.1
March	11:30 a.m.	1.3	1.3	1.7	5.4	8.1	8.8
April	2:18 p.m.	3.3	4.3	—	11.4	10.4	—
May	4:12 p.m.	6.9	5.7	—	12.0	13.2	—
June	5:19 p.m.	7.7	5.5	5.6	12.0	11.8	12.8
July	16h 40m	4.6	3.6	5.3	11.2	11.8	14.3
August	15h 0m	4.4	3.7	5.0	10.3	10.9	12.1
September	12h 40m	4.1	4.1	4.8	9.7	10.1	10.2
October	10h 18m	1.6	1.8	2.1	6.0	8.4	8.6
November	8 20	1.0	1.2		7.2	6.9	
December	7 3	0.7	0.3		5.4	3.9	

From this it can be seen that Denmark leaves much to be desired with regard to the use of the chemical effects of direct sunlight. Here, as in northern and central Europe in general, preference is given to electric arc light in this regard.

VIII.

Some cases of alopecia areata treated with concentrated chemical light rays.

Preliminary communication

by

O. Jersild.

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This treatise was published simultaneously in Annales de Dermatologie No. 1, 1899

At a demonstration conducted at Dr. Forch-Hammer's medical society involving 50 lupus patients who had been treated at Finsen's Medical Light Institute, a large number of results from this new therapy were presented to the Copenhagen medical world for the first time—the results, it should be said, exceeded even the wildest were many old — patients, among whom — expectations. The 50 lupus ulcerative cases, all presented with beautiful white, often barely visible cicatricial lesions, and even upon the most careful examination, no nodules or infiltrations could be detected in the skin. The scope of Finsen's invention can still hardly be determined; however, this much is certain: a method here Finsen's Medical Light Institute. 8

which opens up broad therapeutic, especially dermatotherapeutic, future prospects.

There is no doubt, as the investigations of Finsen 1) and his collaborators 2) have proven, that chemical light rays in concentrated form are among the most effective bactericidal agents known to man, and that their effect penetrates deep into the tissue without altering it or causing harmful side effects. A more ideal treatment for parasitic skin diseases can hardly be imagined. The requirements that must be placed on the light are, first, that it be strong enough; second, that heat rays are excluded as much as possible; and finally, that it is applied for a sufficiently long time

One condition particularly suited to treatment of this kind is alopecia areata. As is well known, the dispute over the etiology of this affection is long-standing, but, as far as one can judge, even earlier anti-contagionists in Germany seem to have subscribed to the long-defended infection theory of the French dermatological school. In this regard, it is interesting that Lesser, in his latest edition of The Textbook of Skin Diseases, in contrast to his earlier view of the disease as a completely nervous affliction, now recognizes two forms: the trophoneurotic and the parasitic. It is remarkable that this admission is coming so slowly, especially when one considers the convincing and epoch-making work that has come from France (Sabouraud et al.) in recent years on the question of etiology

1) FINSEN: On the application in medicine of concentrated chemical light rays. Leipzig 1899.
2) See Bies and Larsen's article.

I am not blind to the need for as much material as possible to draw conclusions regarding therapeutic results, especially when dealing with a condition that, like alopecia areata, tends toward spontaneous recovery, certainly often only after it has existed for years. Since the condition is quite rare in this country, we have considered it most correct to draw attention now to this treatment, which will hopefully prove to be rational; otherwise, several years might pass before sufficient material would be available

I collected my cases in the department of skin diseases at the polyclinic; some of them were sent by private physicians. All patients were treated at Finsen's Medical Light Institute.

I would like to express my sincere thanks to Professor Finsen for his kind kindness and for permission to publish the cases, and to my supervisor at the polyclinic, Dr. Ludwig Nielsen, for providing the patients.

It is never a good sign when the number of treatments and remedies proposed for a condition is large. As for alopecia areata—a disease whose treatment has particularly absorbed the attention of physicians—one has only to consult the larger manuals to see that the results have scarcely corresponded to the ingenuity and effort applied. This is also admitted by most dermatologists, who consider therapy completely powerless against the disease mentioned here and place their hope in time and its spontaneous recovery. To cite just one 8*

cite a few examples, KAPOSI says: 1) "Therapy seems to be based on this disease, but is entirely positive and, as empirically as possible, of all certainty; it cannot be prolonged, nor can it be determined that it will break at a new point. — To The rest time seems better than anything that can be done," and LESSER 2) claims that there is no remedy that can stop hair loss or promote new hair growth and suggests the commonly used remedies "out of aliquid fiat." All the various French methods (VIDAL, BESNIERS' treatment, etc.) have two main aspects in common: 1. the local application of irritants and 2. general prophylactic antiseptic treatment of the scalp. SABOURAUD[3], who, as is well known, identified a possibly specific form of bacteria (microbacille de l'utricule peladique) in alopecia areata, assumes that the toxic effect of this bacterium on the papilla is responsible for hair loss. In his opinion, the application of local irritants is rational because it facilitates the excretion of stagnant, harmful metabolic products. In contrast, antiseptics are said to be ineffective on the patch itself, as they do not penetrate deep into the scalp.

If we seek clarification about the results of these treatments recommended from France, we find the following in Brocq: 4) The treatment by M. Dr. E. Vidal gave us rapid results: it can cause a characteristic peeling by medium-large plaques.

1) M. Kaposi: Pathologie et traitement des maladies de la peau. Translated by E. Besnier and A. Doyon. 2nd edition, II. Paris 1891, pages 194-196.
2) Lesser: Lehrbuch der Haut- und Venerealkrankheiten I. Leipzig 1896
3) SABOURAUD: Clinical and experimental study on the origins of skin eczema. Ann. de dermatologie 1896.
nis 4) BROCQ: Treatment of skin diseases. Paris: 1892.

in three to six months; it is almost the same as that of M. and Dr. E. BESNIER.

The fastest French methods therefore last at least 3-6 months

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Before I proceed to give a brief account of the case reports, I consider it most correct to emphasize the properties of light on which the treatment of what I consider to be a parasitic condition, "vulgaris pimples," i.e., the infectious, sometimes epidemic form of alopecia areata, is based, and to give a brief description of the procedure that was used here.

The factors in the effect of light that are initially of decisive importance are:

1. The bactericidal, deep-penetrating effect of light.
2. The hair-growth-inducing effect of light.
3. The induction of local skin inflammation by light

1. The bactericidal effect of light has been proven by numerous investigations (Downes and Blunt, Duclaux, Arloing, Geisler, Buchner, D'Arsonval, and Charrin); the deep bactericidal effect is proven by Finsen's experimental investigations, 1) as well as by the tangible results of lupus treatment.

2. As far as I know, there are only a few studies by one author in the literature on the influence of light on the growth 2) of nails and hair, according to which light is supposed to promote hair growth. Some popular

1) Finsen: 1. c. p. 29. Bibliographies included. 2) Bertold: Müller's Arch. f. Anatomie und Physiologie. 1850, p. 156

Observations, which I mention in passing, without attaching much importance to them, seem to point in the same direction. It is an old, well-known popular observation that shaving and cutting hair are more often necessary in summer than in winter; furthermore, it is generally known that it is much easier to grow a full beard in the southern zones than in our northern climate. However, there are also actual clinical observations in this regard; for example, it is a fact, which I can substantiate with some journal excerpts, that one often sees more abundant hair growth in the area of light-treated lupus lesions than in other parts of the skin.

Case report I. K. R., 21 years old, unmarried woman. Lupus erythema. Treatment began in 1996

On January 16, 1997, it is noted: The spot on the right cheek is surrounded by a fringe of strong hairs; these only developed about a month ago, when the spot was healed. The spot was treated with electric light for only 4 hours during the first few days of September.

Case report II. E.R., 9 years old, daughter of a pilot. Lupus vulgaris. Treatment began in 1996.

On January 15, 1997, it is noted: The hair growth (the lanugo hairs) outside the cicatrice on the healthy skin is more abundant than on the rest of the skin.

On April 14, 1997, there is some pigmentation of the healthy skin around the previously affected spot, and there is an abundant growth of lanugo hairs.

On April 24, 1997, the hair growth is more abundant around the edge of the cicatrice, especially downwards and backwards, than on the rest of the cheek

These observations, compared with the statements of the nurses working at the light clinic, according to which their arms, exposed to the strong electric lighting, grow more hair than before, seem

to support the view that the light has hair-growth-stimulating properties

3. There is no doubt that the vigorous application of irritating agents and the resulting skin hyperemia 1) are largely responsible for the results the French authors claim to have achieved with their treatments. In the light treatment of alopecia areata, local dermatitis is certainly also a factor of some importance. That redness and subsequent exfoliation — because of the skin, and in more severe cases even bulla formation, can be caused by the action of the light rays is observed daily at the institute. However, it must be emphasized that the local reaction in almost all cases remained within the limits of the slightest skin inflammation, and one can therefore hardly assume that it played a significant role in the results
achieved

All cases were treated with electric light (arc lamps of 50-80 amps). I cannot say whether sunlight possibly has a stronger effect; from the outset, I am inclined to assume it is analogous to the results in the treatment of lupus.

The apparatus is known from Finsen's earlier communications, to which I refer; 2) I only add that all cases of alopecia were treated with the latest apparatus using rock-crystal lenses.

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1) It is quite interesting that the latest French treatment for alopecia areata (Jacquet: Traitem, de la pelade par l'irritation aseptique simple. Ref. i Sem, méd. 1898 No. 26) aims to induce the desired skin hyperemia by mechanical means (brushing the spot and its surroundings).

See, incidentally, Sabouraud's previously cited interpretation of the effect of local irritants,

-150 2) Finsen: 1.7c.ni stall

I will give a brief description of the treatment of the spot itself. In order to be able to influence the actual growth zone directly and unhindered, we shaved the area surrounding the spot to a circumference of approximately 1.5 cm; epilation was not used. The entire spot and the shaved zone were then illuminated in daily séances, usually lasting 5.5 hours. With larger spots, we occasionally had two séances in one day. When the entire spot had been illuminated (the time required for this is, of course, proportional to the size of the spot), the treatment ended, and another spot was treated. Once all affected areas had been illuminated once, the patient was dismissed with a request to return for observation

To prevent the spread of the disease, the healthy parts of the scalp were treated with daily soap and sublimate washes. Infected headgear was naturally confiscated, and orders were given to disinfect combs, hairbrushes, and the like. The use of sponges for washing was also prohibited. This was done with hygroscopic cotton swabs; these are thrown away after use.

Finsen has shown that an important condition for the deep action of chemical light rays is that the affected area be drained of blood as much as possible. For this purpose, pressure glasses are used at the Light Institute. In the first cases of alopecia areata treated, compression was also used on the patch; however, in those treated later, it was not necessary to drain the skin, probably because the bacteria in alopecia take up residence in far more superficial areas

superficial layers, such as the tubercle bacilli have in lupus skin diseases.

Since it is impossible to completely exclude heat rays, cooling of the illuminated skin areas is necessary. The pressure apparatus used consists of two rock crystal plates set in a metal ring, between which cold water is introduced. When the pressure apparatus is not in use, the skin can be cooled by occasionally moistening it with cold water.

The treatment is completely painless if carried out correctly.

Case reports.

I. Philipp H., 15 years old. The son of a tailor. Started on 3/9/97.

History: No information about infection. The disease was noticed at the beginning of June; at that time it was a bald spot 1 cm in diameter that had been constantly growing

Status praes: A completely bald patch measuring 6 x 4 cm between the ear and the midline of the head. The lowest edge of the patch a few cm below a line corresponding to the uppermost edge of the ear. Bulbous thickening of the hair.

Treatment began: 3/9 97

Treatment ended: 249 97 after 8 séances of 1/2 hour each.

4/10 97. Fine lanugo hairs on the patch.

5/11 97. Normal hair growth, no bulbous thickening of the hair.

12/1 98. Rec. in loco. A 2.5/2.2 cm area where there is no hair, tapering downwards, remains.

Treatment will be resumed on 12/1 98.

Treatment ended on 16/1, after 5 séances of 1 hour each

22, 98. Fine, small hairs on the aforementioned triangle.

29, 98. No hairs are found on the scar 1); otherwise, the hair growth is just as strong as on the rest of the head.

11/7, 98. Always a clean scar after the burn. Incidentally, a completely thick hair growth; no loose hairs.

21/10, 98. Always unchanged. Thick hair of normal color.

Observation period approximately 9 months after the interruption of treatment.

II. Mette N., 52 years old, married to a tailor. Beginning on 24, 98.

History: No information about infection. The condition began shortly before Christmas with a spot above the left ear. The spot has continued to grow. Only soap washes (naphthol soap) have been used.

Status praes: A spot 85 cm above the left ear, almost completely hairless

2. A spot 33 cm above the right ear.

3. A spot 22 cm on the vertex.

The treatment began: January 24, 1998.

The treatment ended on February 14, 1998 after 29 séances of one hour each.

In the 29 séances, spots 2 and 3 were treated, as well as the anterior edge of spot 1. No strong reaction, only some redness.

January 1, 1998. The patient has not returned so far.

Spot 2: recovered.

Spot 3: likewise.

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1) A bulla 2 cm in diameter appeared upwards and inwards after treatment of the shaved area. It left behind a scab, which was sloughed off in September. The spot where it had been was red and scar-like.

Patch 1: The front part covered with fairly thick, fine, gray hairs, no hair loss.

In the part towards the back (not illuminated), the patch has spread quite significantly.

Treatment restarted: 1/7 of 98 from the rear part of the patch + further spread.

Treatment stopped: 19/98 after 14 séances.

21/10 of 98. Abundant, normal hair growth with firmly attached hairs all over the patches. The hair growth on the patches is very gray, while the remaining hair is completely black.

Observation time after the interruption of treatment: approximately 8 months for the first treated areas and approximately 3 months for the last treated patch.

III. Helge H., 15 years old. The son of an iron dealer. Started on November 11, 98

History: Books taken to an official's assistant who was said to have had the same illness. Started with spots 1 and 2 3 months ago. Spot 1 has grown particularly significantly. Treated with alcohol.

Status praes: 1. A spot 53 cm a little to the left and in front of the vertebra.

2: A spot 32 cm: just to the right of the vertebra. Loose hair around the circumference, slightly curved edges. Nostalgic

Treatment started: 1.5 1998.

Treatment ended: 22.98 after 2 séances.

27.3 1998. The suffering appears to have improved, as the hairs are natural along the edges of the spots, and there is abundant hair growth everywhere.

2.5 1998. Healthy, increasing hair growth on the old spots. 3 new spots have appeared:

3. A spot 1/2 cm in diameter, round, above the left ear.
4. A spot 1 1/2 cm in diameter, just in the vertex next to the old spot 2.
5. A spot irregularly shaped, to the right of the vertex.

Treatment started again: 2/5 98.

Treatment stopped: 27/98 after 38 séances.

13/6 98. Spots 1-5 (i.e., all spots) are covered with hair. No diseased hairs in the edges, no dandruff.

21/10 98. No trace of disease. Hair growth and hair color completely normal.

Observation period after the interruption of treatment with regard to the first spots: 8 months, with regard to the latter: approximately 5 months

IV. Agnes K., 9 years old. The daughter of a coachman. Started on April 28, 1998.

History: The illness began 8 weeks ago. Always treated at the outpatient clinic, but the condition has always spread.

Status praes:
1. Round spot, 6 cm in diameter on the neck to the left of the midline.
2. Round spot, 4 cm in the middle of the neck at the hairline.
3. Oval spot, 3 1/2 cm at the crown above the right ear.
4. Round spot, 2 cm in diameter, approximately 4 cm below and behind 3. The spots are completely hairless, smooth, and white. The hair at the edges is loose; there is a bulbous thickening of the hair in several places at the edge.

Treatment started on April 28, 1998.

Treatment interrupted on February 21, 1998 due to a femoral lesion

Treatment resumed: 6/6 98.

Treatment discontinued: 13 98 after 48 séances in total.

6/7 98. All patches are healthy with increasing hair growth.

26/7 98. The same.

21/10 98. Completely normal hair growth; no trace of the disease.

Observation period after the interruption of treatment: 4 months.

V. Johannes S., 23 years old. Student, mag. Started on 16/8 98. History: The bald patch was discovered 14 days ago. Treated with Besnier's fluid (chloral, glacial acetic acid, and ether).

Status praes: One patch 23 cm, a couple of cm to the left of the occipital region. Loose hairs at the edges

Treatment started: 16/8 98. dal Sil

Treatment ended: 18/8 after 3 séances.

26/8 98. The spot unchanged in size, slightly red. In a single spot medially and downwards, a slightly stronger redness and scaling. Individual loose hairs but no bulbous thickening.

Lively, fine hair growth.

Treatment resumed: 179/98.

Treatment ended: 22/98 after 5 séances.

21/10 98. Abundant hair growth. The hair color is lighter than the surrounding areas. On the previously mentioned area, inwards and downwards, the hair growth is always a little thinner.

Otherwise, no suspicious signs,

November 26, 1998. Good hair growth overall. The hair is still a little lighter. In an area about the size of a pea, inward and downward, the hair growth is thinner.

Observation period after the interruption of treatment: approximately 2 months.

VI. Erwin G., 8.5 years old. The son of a baker's apprentice. Started on October 10, 1998

History: The suffering lasted a few months. No treatment.

Status praes: 1. Elongated, irregularly shaped spot, 42 cm in the left parietal region, 5 cm above and a little behind the ear.

2. Round spot 1 cm in diameter in the right parietal region, approximately 10 cm above the ear.

3.6 Small spots on the neck, approximately 5 cm above the hairline, and a narrow spot in the middle of the head with — with thinning hair growth,

Cob-like thickening of the hair at the edges.

Treatment started: 10/10 98.

Treatment stopped: 24/10 98 after 13 séances.

31/10 98 Loose hairs nowhere to be found, culbre

7/11 98. No new spots. Most of the small spots are fairly well covered with hair, but still visible. The spot above the left ear has not grown; a few hairs here and there on it, these are natural. No loose hairs.

21/11 98. Most of the small spots are barely visible; the entire bald spot is growing rapidly. No loose hairs.

Observation period after interruption of treatment: approximately 1 month.

VII. Holger V.-S., 50 years old, cigar dealer. Started on 8/11 98.

History: He believes he was infected by an acquaintance who had pelade décalv. The current spot has grown slowly over a period of 2-3 months.

Status praes: Round spot with a diameter of 3 cm on the left temple. Loose hairs at the edge. No bulbous thickening of the hairs

Treatment started: November 8, 1998.

Treatment ended: November 12, 1998 after 4 séances.

November 18, 1998. Clear downy hairs on the entire patch.

November 26, 1998. Lively hair growth all over the patch. The hairs are still unpigmented. The patch has not increased in size. No loose hairs.

December 20, 1998. Good hair growth on the entire patch that has not grown. No loose hairs anywhere. The hairs are always unpigmented.

Observation period after the interruption of treatment: 5 weeks.

I will make the comments I would like to make on the above-mentioned case reports as brief as possible

To turn immediately to what I consider to be the most convincing and illustrative case, I will highlight Case Report II. The affliction, which is only about one month old, is nevertheless quite extensive, and it is further stated that it is in continuous propagation. When the patient, who had been absent from the light clinic for about 412 months, was referred for examination, the light-treated areas (spots 2, 3, and the anteriormost edge of spot 1) were healed, while the untreated posterior part of spot 1 had widened. This seems to prove that the affliction, despite its undeniable tendency to propagate, was brought to a standstill and recovery directly by the treatment, and further conviction—I might almost say, of the specific effect of the light treatment—is gained , — by this

that the remaining part of the disease also responds to the treatment. The long intervals between revisions due to the patient's unreliability prevent an observation of how quickly the recovery occurred in this case, but emphasize all the more clearly the contrast between treatment and non-treatment.

In the instructive case report III, it seems more convincing to me that the new spots (3, 4, and 5) are covered with hair 17 days after the treatment was discontinued than that the original disease (spots I and 2) was relieved 13 days after the treatment was completed, and barely 3 weeks after the patient appeared at the light clinic. For the cessation of the original disease, which was already three months old, could at times, albeit somewhat forcedly, be explained as a result of spontaneous recovery, to which alopecia areata is prone, whereas this cannot really be assumed with regard to the infection that arose later

On the whole, all cases show an unexpectedly rapid reaction with regard to hair growth. In Case Report I, we see lanugo hair 12 days after treatment was discontinued (i.e., 1 month after the start of the course), and normal hair growth after about 2 months. The small recurrence in loco mentioned in this Case Report was already covered with fine hair 10 days after it was diagnosed and treated.

The longest period of recovery (2.5 months) is found in Case Report IV. The affection is, after all, very widespread here and constantly spreading; in addition, one must note an interruption in treatment of 16 days due to a femoral lesion.

The shortest reaction time is in Case Report VII, where downy hairs are present on the patch 6 days after the end of treatment and 10 days after the start of the course.

The club-like thickening of the hair mentioned by Sabouraud, the presence of which indicates that the condition is spreading, was present in three of the cases; loose hairs in the edges are noted in four of the case reports. In five of the anamnesis, it is stated that the patients themselves noticed the continued growth of the patches.

Recurrence in loco is found only in case one (Case Report I). The patches that reappeared at other locations on the head in Case Report III cannot be attributed to the light treatment, at most to the general antiseptic treatment of the scalp.

The longest observation period with regard to recurrences after the cessation of treatment is 8-9 months (Case Reports I, II, and III).

The only time an accident occurred during treatment was in Case Report I, where a small burn left permanent baldness. In all other cases, the local reaction did not exceed the limits of the desired, superficial dermatitis. As with the other treatment methods and with spontaneous recovery from the condition, the first hairs to appear are fine, unpigmented lanugo hairs. The pigment deficiency can persist even after the hairs have regained their normal shape (e.g., in Case Report V). The hairs in Case Report II have undergone a very peculiar change, where their color is gray, even after they are completely identical in length and thickness to the other black hairs. The explanation can only be sought in the patient's age (52 years). Finsen's Medical Light Institute. 9

The disease has certainly affected the hair papillae in such a way that the regenerated hairs have prematurely achieved the venerable color which the onset of senility only imparts to the other head hairs somewhat later.

I cannot comment on how the treatment affects the very widespread forms (decaying hair). I hope that these forms, which arise from the growth and confluence of scattered patches, can be avoided by early treatment of the individual propagating alopecia.

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NOTIFICATIONS

FROM FINSENS MEDICINSKE LYSINSTITUT (FINSENS MEDICINISCHES LIGHT INSTITUTE) IN COPENHAGEN

II

EDITED BY PROF. DR. NIELS R. FINSEN

THE GERMAN EDITION PUBLISHED

FROM

DR. VALDEMAR BIE

LABORATORY ASSISTANT AT THE INSTITUTE

LEIPZIG

PUBLISHING BY F. C. W. VOGEL 1901

Foreword.

This volume contains the second and third volumes of the Danish edition; two articles have been omitted because they have already been published elsewhere, namely Professor Finsen's: Light as Incitament (On the Significance of the Chemical Rays of Light for Medicine and Biology. Three Essays by N. R. Finsen, Leipzig 1899) and Professor H. Mygind's: Lupus Vulgaris Laryngis, a Clinical Investigation (Archives for Laryngology, 10th Vol.).

Dr. Th. Schüler in Berlin has shown us the kindness to correct the translation of this volume as well as that of the previous one.

Copenhagen, December 1900.

Valdemar Bie

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I. The Effects of Light on Microorganisms
by

Sophus Bang.

1) A New Method of Investigation.

Despite the numerous works of recent years on the effects of light on bacteria, the more than twenty years of work by Downes and Blunt on this subject still occupies the leading position. On the whole, their results have been confirmed; moreover, we have been enriched with a wealth of detailed knowledge. However, only a few later researchers have succeeded in introducing new guiding viewpoints, and the opinions of the individual authors diverge so widely that, when studying the relevant literature, one gets an impression approaching chaos.

This leading position of the works of Downes and Blunt deserves to be emphasized all the more because the great distance between them and the majority of their successors is usually not sufficiently emphasized. Certain imperfections must, of course, be inherent in experiments on previously unknown ground, but they made no different experimental errors than their successors

One has to be amazed at how versatile Downes and Blunt were right from the start. They not only established that both diffuse daylight and direct sunshine can inhibit all kinds of bacteria, both spores and vegetative forms, or, with prolonged exposure or greater intensity, kill them. They also demonstrated that this effect is mainly due to the most refractable rays, and they demonstrated through control experiments that it is not the warmth of the sun that is important, but its light, and that the effect occurs both when the bacteria are moist and when they are dried, although the medium surrounding the bacteria influences the time required for the light to act. They further demonstrated that the presence of oxygen is necessary, and even that the light effect is, to a certain extent, proportional to the oxygen tension They recognized the possibility that the effect of light could consist in a modification of the nutrient substrate, but they found that this was not the case in their experiments. They even considered the possibility that light could affect the metabolic products of microbes, finding that a cell-free yeast infusion loses its ability to convert cane sugar into glucose when exposed to light, and that this effect of light is also linked to the presence of free oxygen.

All of these results have been increasingly confirmed by later investigations. New findings of fundamental importance have appeared only sparsely since then. For example, Marshall Ward demonstrated the great importance of ultraviolet rays. Roux demonstrated that broth, after sufficiently long illumination, can become a less favorable medium for the germination of anthrax spores. However,

Later investigations have shown that this effect, although not without theoretical interest, is nevertheless, from a practical point of view, of subordinate importance compared to the directly killing effect on the bacteria themselves, since it only becomes apparent after very long and intense illumination. However, one cannot yet speak with complete certainty about this point, because truly quantitative determinations are still lacking. It is equally Richardson and Dieudonné are — uncertain whether right to assume that the effect of light is based on the formation of hydrogen peroxide. Arloing's attempt to prepare vaccines using light-weakened bacteria must also be mentioned as something new, which arose after Downes and Blunt.

Naturally, the later investigators improved the experimental setup in that they worked with pure cultures, whereas Downes and Blunt worked with random mixtures of bacteria from putrefactive liquids, the air, etc However important this advance is, one must not forget, on the other hand, that it was simply a consequence of the development of bacteriology, the first work by Downes and Blunt appearing in 1877 (the first relevant work using a pure culture in 1885). Nor should one overestimate the significance of this advance; for that light could kill the bacteria of a pure culture could probably be predicted with a fair degree of certainty, given that it had already been established that it could kill all possible random mixtures of bacteria, just as they occur in nature. What one should, in principle, have achieved first and foremost by using pure cultures—namely, an exact determination of the conditions under which each individual bacterial species is killed, so that one could—

The progress made through new biological insights into bacteria has, as I will explain below, so far only been made to an extremely modest extent, mainly because insufficient consideration has been given to the physical conditions.

One gets the impression that most work in this field has been carried out by more or less good bacteriologists, but by poor physicists. There are a few, but all the more fatal, errors that appear again and again in the work of various authors. Firstly, one only very rarely finds an exact indication of the light intensity used, although one would think that this factor must play the same role in investigations into the effects of light as temperature measurement does in thermodynamics. Where it is a matter of investigating the effects of sunlight or daylight, there is nothing to object to; For it is, of course, important to know that "the sun" kills this or that bacterium in so many hours, even if we are not told how strong this sun was; but I find it unforgivable when, for example, Dieudonné, to name one among many, states that an electric arc light of 900 candles can kill bacteria in a certain time, but does not state at what distance from the light this occurs, or when he does not state either the strength or the distance of the incandescent light used. Perhaps even worse is the case with all those authors who investigate the effect of individual colors. All those who use light filters (e.g., ARLOING, d'ARSONVAL & CHARRIN, BECK & SCHULTZ, BILLINGS & PEEKHAM, BOCK, DIEUDONNÉ, DOWNES & BLUNT, SERRANO FATIGATI, GAILLARD, GEISSLER, JANOWSKY, KOTLJAR, KRUSE, LAURENT, LEDOUX-LEBARD, LÜBBERT, SANTORINI, WARD)

omit information about the attenuation of light in the individual spectral regions. The most conscientious researchers determine spectroscopically which types of rays pass through the filters; but how much passes through them remains unknown, and yet they make comparisons between the different spectral regions. Such investigations are of the same value as if someone wanted to investigate whether coal or wood provides the best heat without knowing how much is used for heating

Nor has it been determined what percentage of the light penetrates the bacteria. There are only extremely few experiments where, even with the best will in the world, one can only estimate how much light penetrated into the interior of the culture, i.e., to the place where the bacteria were located. With few exceptions, the authors enclosed their cultures in glass vessels. If at least plane-parallel glass plates had been used, one could in some cases calculate the amount of light that penetrated to some extent, provided the angle of incidence, the reflection, and the absorption in both the glass and the nutrient medium were taken into account. But in reality, most researchers have used test tubes, flasks, and similar vessels that are difficult to define optically, and we are therefore faced with only unknown quantities. Of course, it is of great interest in itself to know whether, for example, For example, the effect that sunlight can have on bacteria enclosed in glass vessels is more in practical than in biological terms, since one must realize that when using glass, among other things, a very large portion of the ultraviolet rays is excluded.

The significance of this, at least from an optical-physical point of view, becomes clear from the following experiments, which I conducted with Larsen's actino-

meter. If one allows electric sparks from a Ruhmkorff to jump between two metal poles, and then moves them far enough apart that the sparks no longer jump, one can cause the sparks to jump again when the rays of an electric arc lamp fall on the negative pole, despite the increased gap. If such an apparatus was held at a distance of 30 cm from an arc of 35 amperes and 50 volts, with the rays emanating downward at an angle of 450° to the axis of the carbons, the sparks could just jump over at a certain voltage if the metal poles were 2.55 mm apart. At 2.56 mm, they no longer jump over. If a 10 mm thick quartz plate was inserted between the arc light and the spark path, this relationship did not change noticeably If, however, an opaque body (e.g., cardboard) was inserted, sparking only occurred when the poles were brought within a distance of 0.43 mm and ceased again at 0.44 mm. If, instead of cardboard, a glass plate 0.07 mm thick (i.e., about half as thick as an ordinary cover glass) was used, the poles had to be brought closer together to within 0.13 mm to produce sparks, and this again ceased at 0.44 mm. In other words, while 10 mm of quartz does not retain a measurable amount of the actinic rays in question, 0.07 mm of glass does not allow any measurable amount of them to pass through. Marshall Ward demonstrated through direct experiments, namely through spectra produced partly by glass prisms and partly by quartz prisms, that precisely this type of radiation, which passes through quartz but is absorbed by glass, has a strong bactericidal effect.

If you use glass containers for your cultures,

you must therefore be clear that you are thereby excluding a certain proportion of the rays. In this context, it is characteristic to me that Buchner, in his work on the self-purification of rivers by light, managed to kill the bacteria in a much shorter time than earlier researchers, for example, in just one hour, by exposing the germ-laden water to the sun in open containers; whether he was clear about the role the glass played in the other experiments is not clear from his work.

In certain experimental setups, refraction plays an even greater role than the absorption of the glass When numerous researchers (e.g., Arloing, Janowski, Kruse, Ledoux-Lebard, Raspe, Tizzani & Cantani, Tyndall, Marshall Ward) used a nutrient fluid in test tubes or similar glass vessels, refraction became of crucial importance. The convex surface of the glass, as is well known, refracts the rays so that they converge toward the center of the fluid, while the side portions of the fluid remain in darkness. The following experiment demonstrates how complete this darkness can be: Hold a test tube filled with water close to a piece of photographic silver chloride paper and allow the sun or arc light to shine on the glass. After a few moments, the paper becomes blackened, partly around the glass, partly along a very narrow focal line behind the center of the glass. On both sides of this line, one sees a broad stripe where the silver paper remains completely white; thus, no light effect has taken place here. Therefore, no significant light penetrated the corresponding spots inside the liquid. One can only be amazed that it was even possible to

to kill in this way. Apparently, it is only possible if the fluid is circulated, so that each individual part successively enters the illuminated area; but that the time necessary to sterilize the fluid is thereby much longer than if all parts were illuminated at once is undeniable. Therefore, we also see that the authors' time estimates are, on average, much higher than mine, insofar as it is at all possible to compare the times (see the experimental protocol, Section II). Of course, it is correct, indeed necessary, to conduct such experiments because they approximate certain naturally occurring or practically important conditions; but one must always remain aware that this investigation does not concern the speed with which a bacterium is killed by light, but the speed with which a given quantity of fluid can be sterilized under the given conditions The fact that there was uncertainty about this has led to hopeless disagreement over the time estimates given by individual researchers, and some researchers, such as Lübbert, Beck & Schultz, Raspe, and Uffelmann, have even obtained completely or partially negative results.

The experimental setup can be somewhat better if a solid nutrient medium enclosed in glass vessels is used; but here, too, the irregular refraction in unground glass plays a role as soon as one attempts to determine limiting values, as this distributes the light unevenly over the surface of the culture. Furthermore, the agar or gelatin and the substances mixed with them will themselves absorb the light, particularly its short-wave part, and the result will thus depend, among other unpredictable factors, on how deeply the bacteria are embedded in the nutrient medium.

regarding the thickness of the agar or gelatin layer. This also applies to the otherwise very useful Buchner method, which aims to illuminate a plate culture from the underside (i.e., the side in contact with the glass) in such a way that only certain parts of the culture are illuminated, while immediately adjacent parts remain protected from the light, by means of opaque letters written on the glass or in a similar manner. If, under these circumstances, an illuminated section appears sterile after a certain illumination time, one can, strictly speaking, only conclude that the illumination in question kills even those bacteria that were most protected by the agar layer. When the effect began on the bacteria that were on the side of the agar layer facing the light remains unknown This method can be used where it is important to compare the properties of different light sources, but it is less suitable for biological questions, where the primary objective is to determine the minimum killing time for a particular bacterium. In earlier investigations at Finsen's Light Institute, it was believed that the Buchner method could be improved by determining the time at which the first visible "attenuation" of the bacteria became apparent, but this was done with an unclear definition. The first visible attenuation meant that the illuminated spot, after all surviving bacteria had grown out, would appear somewhat less cloudy than the unexposed parts of the nutrient medium. However, this would occur when the light intensity (or exposure time) was just high enough to kill the bacteria in the part of the nutrient medium closest to the light source, while the light in the deeper layers of the nutrient medium was so attenuated that

weakened by absorption was that they did not die here. What was demonstrated, therefore, was not a weakening of the bacteria: only some were killed and others left alive, whereby the number of growing colonies decreased; in other words, one demonstrated not a weakening, but a "dilution." Moreover, whether a real weakening of the individual bacteria occurred is difficult to determine in this way; in any case, no proof of this has been provided so far. And the only conclusion that can be drawn from the experiment is the following: The light in question was just strong enough to penetrate a "visible" distance into a nutrient medium of the respective color and transparency, seeded with bacteria of the respective density, without losing its bactericidal properties—all factors that contribute to the result, but are difficult to keep constant or express numerically If, on the whole, so little consideration has been given to such drastic sources of error as all those mentioned above, one should not be surprised that the results of various researchers differ so much from one another. Thus, it is hardly even possible to compare them with one another; indeed, it is sometimes difficult to understand how an individual researcher could obtain consistent results within his own series of experiments, especially when the deviations that I will demonstrate experimentally below are added to these. If the theory of the relationship of bacteria to light is to assume the place in biological science that it certainly deserves, given the role this relationship plays in the economy of nature, much greater emphasis must be placed on quantitative work than before. The fact that the first investigations in a completely new field are, by and large,

are mainly qualitative, is not surprising, and such investigations are of great importance as groundbreaking and stimulating. But one gradually reaches a point in this science, as in every other, where it becomes necessary to "weigh and measure." And the measurement here must be twofold: partly, certain effects of light can be measured using microbes, and partly, certain properties of microbes can be measured using light. Both types of measurements must be carried out, but primarily, it seems most natural to me to start with light, as the best known of these factors. Light must be the precisely weighed reagent with which we seek to measure new aspects of the bacterial lifestyle; but this only becomes possible when we take precise account of the physical conditions. An improved method of investigation is the conditio sine qua non.

The method I use

In order to achieve the most precise dosage of light, I attempted to create an experimental setup whereby the light beam encounters as few and as small obstacles as possible on its path from the light source to the bacterial body, and where the obstacles that cannot be avoided can be assessed and measured.

I believe I have found a reasonably satisfactory solution to this problem in the application of the apparatus described below, which uses as few and as simple reflecting surfaces as possible, as little absorption and refraction as possible, constant temperature, and the possibility of

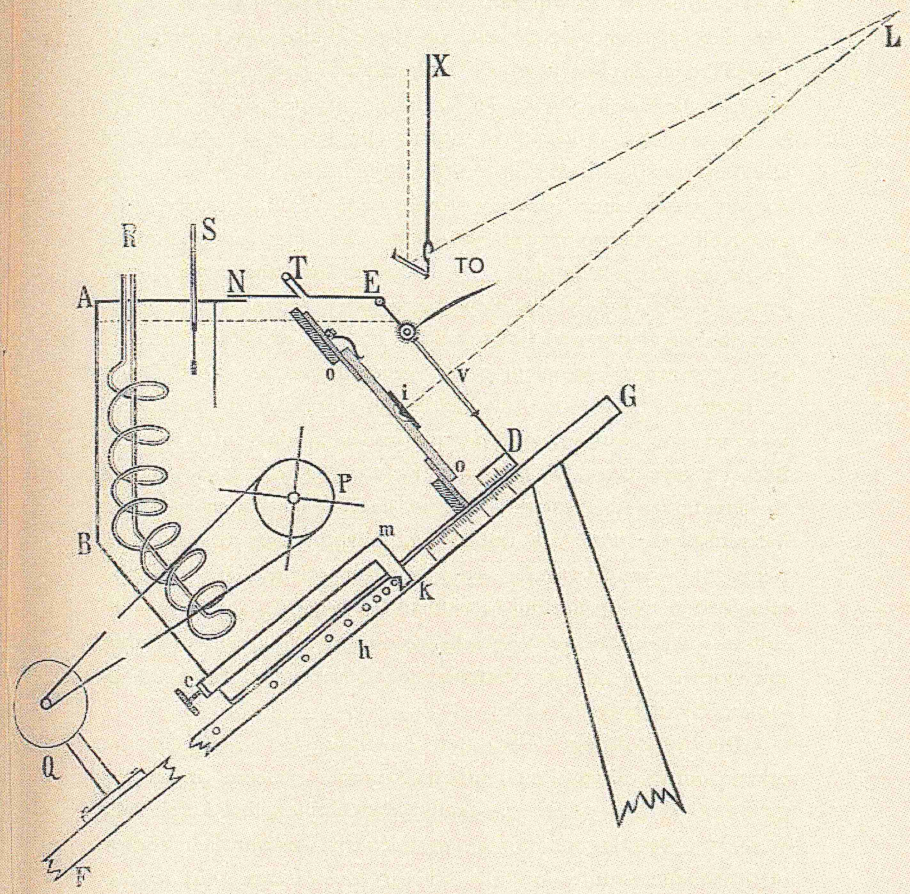
to be able to vary its intensity in a calculable manner.

I will describe here the setup and arrangement of the apparatus when using electric light; with appropriate modifications to the setup, it can also be used for sunlight.

Before I discuss the details, I will note for orientation that the principle used consists in spreading the bacterial culture in the thinnest possible layer, e.g., as a hanging drop, on a thin quartz plate. This quartz plate is applied as the ceiling of a "humid chamber." This chamber (hereinafter referred to as the "culture apparatus") is placed in a box filled with water. This water is kept in constant flow and at a constant temperature by a wheel. The light is admitted through a quartz window in the side of the box

The light source. The electric arc lamp (see L in the figure) is suspended in the manner customary at the Finsen Light Institute, so that it can be moved up and down, as well as in all directions, and fixed in any position using screws. The carbon thickness is chosen empirically so that the arc always maintains the same position in space as far as possible. Since this is difficult to achieve with absolute accuracy, as one carbon usually becomes somewhat shorter than the other after a longer period of time, thereby shifting the arc somewhat, I have always conducted the experiments with freshly inserted carbons of a specific length. During the course of a normal series of experiments, 1 to 2 hours, the arc does not noticeably change its position; however, for longer experiments, it may be necessary to lower or raise the lamp slightly. To adjust the position of the arc

To check this precisely, I attached a small projection device (Z) to the screen surrounding the lamp (X);



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This consists of a biconvex lens and a plane mirror, through which an enlarged image of the carbon tips and the arc is projected onto a screen on the wall of the laboratory

drawn scale. Every change in the position of the arc is immediately apparent in this way and can be corrected immediately. It is also of the utmost importance to continuously observe the arc in this way in other respects. Even if one places one carbon as precisely as possible in line with the axis of the other, it very easily happens that the "crater" of the positive carbon burns crookedly, causing the light to be thrown more strongly to one side. For experiments that are carried out immediately one after the other and are only to be compared with each other, this circumstance does not play a major role, since a crater that is not too crooked will retain the same direction and shape for hours; but in order to be able to compare experiments that are carried out after longer intervals, one must avoid crookedness in the crater formation, which is made much easier by monitoring the carbon tips from the beginning using the aforementioned projection device In the series of experiments described below, I always used a current of 35 amperes with a voltage of 50 volts. Regarding the accuracy of the regulation, I refer to the experimental protocol reproduced below. The positive carbon (the upper one) in the lamp used had a diameter of 24 mm, the negative one 15 mm.

The setup. In front of and below the lamp is a rectangular board (FG), which is firmly positioned at a certain angle to the axis of the carbons. The light emanating from the arc is, as is well known, distributed extremely unevenly in space; the largest amount radiates obliquely downwards in a belt between 450 and 550 degrees with the axis of the carbons; above and below this belt, the light intensity falls very rapidly. Which angle is chosen is, in itself, quite unimportant for comparative experiments; only

one must always choose exactly the same one I have provisionally chosen 45° for external reasons, but I do not recommend this angle as the most suitable, because a slight lack of precision in the setup becomes more significant than, for example, with 50°, because the former angle is too close to the point where the luminous intensity decreases sharply with increasing angle. If a different angle is chosen, one must consider the possibility that not only the luminous intensity but also the relative proportions of the various colored rays can change with the angle of radiation (incidentally, I later attached the board to the lamp suspension so that it can be mounted in all radial positions, with the arc as the center). Not only must the board be at the angle in question, but the extension of its surface must also intersect the axis of the lower carbon so deeply below the arc (at the size ratios given below, approximately 6.5 cm below the tip of the lower carbon) that the rays that hit the center of the quartz window run parallel to the surface of the board.

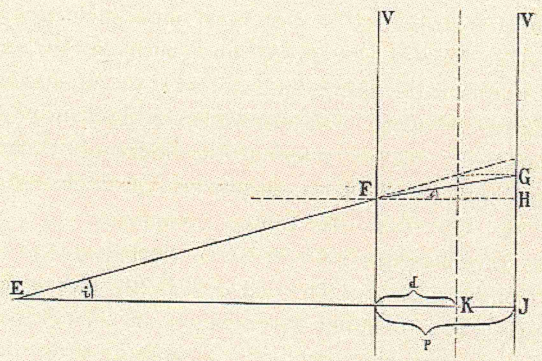
The sheet metal box (ABCDE), in which the culture apparatus is to be mounted, is attached to the board by means of the brass bracket (cmk); at k, it is provided with a notch, with which it is attached to one of the pins (2). These are placed on the sides of the board at such intervals that the luminous intensity at the point inside the box where the cultures are located takes on the values 10/10, 9/10, 8/10, etc., depending on the pin used. The calculation of these distances is, of course, done using the law of decay of luminous intensity inversely proportional to the square of the distance. If we set the unit as the exposure L that occurs at an arbitrary distance a from the light source, we have

the distance, A, where the illumination is of the desired magnitude /, in the formula: A = a V

If, for example, as I did below, one takes the illumination at a distance of 280 mm as the unit, one has

Illumination 1.0 at a distance of 280 mm

-	0.9	- 295	-	-
-	0.8	- 313	-	-
-	0.7	- 335	-	-
-	0.6	- 361	-	-
-	0.5	- 396	-	-



However, it must also be taken into account that the rays come somewhat closer together because they are refracted in the water layer in front of the culture, whereby the illumination becomes somewhat stronger than the distance would suggest. If VV represents the boundaries of the water layer, its thickness, and E the light source, the ray EF will take the direction FG in the water; the light filling the angle ż will thus concentrate on the surface space GF, which space it would have occupied without the water layer at

distances EK. If i is the angle of incidence, b the angle of refraction, and n the refraction ratio of the liquid, then one has

p.tgb P = = d. tgi tgi tob' if.

d/GH = the angle

of incidence is small (see below), one has tgi sin i tg b

sin b =
n

To obtain a quantity of light corresponding to distance A without a water layer, one must take the

distance A+p+d=A+p(1) ÷ 1/n)

with a water layer. If one calculates the refractive ratio of the water - 3/4, the distance must therefore be equal

to A+P 4/

The finer adjustment of the box is done by means of two screws (at C), partly so that the distance between the light source and the culture is the desired one, and partly so that the front surface of the box (ED) is exactly perpendicular to the direction of the light rays used (Li). The result can be seen by means of special marks on the sides of the board and on the box (at D). These marks were originally marked by attaching a small piece of mirror glass to the middle of the front surface of the box and then adjusting it so that the reflection of the arc is reflected back into the box itself, which only occurs when Li ≤ ED

The front surface of the box has a circular window (2) made of a 1.5 mm thick, plane-parallel ground quartz fins Medical

plate; this plate is cut perpendicular to the optical axis of the crystal. The diameter of the window is 43 mm, and its center is 5 cm above the bottom of the box. With the setup discussed above, a straight line from the arc will run through the center of the window, parallel to the surface of the board. This is very important if one wants to compare the effects of different light intensities by moving the box along the board; for in the opposite case, for example, if one had placed the box further down on the board, one would not only have changed its distance from the light, but it would immediately receive rays emanating at a different angle to the axis of the carbons, thereby introducing entirely new moments (cf. pp. 14-15). Since the arc light does not emanate from one point, but from the crater of the upper carbon, the arc, and the tip of the lower carbon, one must define more precisely what is meant by the "distance of the light," and this is particularly important when the distance is not large. It is very difficult, given our current state of knowledge, to say which measuring point is the best; the first experiments reproduced below (series 1-36) were all carried out at the same distance; I was therefore able to use the most convenient measuring point in practical terms without hesitation, namely the point closest to the culture on the narrow white ring that forms on the positive carbon a few millimeters above the rim of the crater; it also corresponds fairly well to the nearest part of the strongest light, since this ring forms on the boundary between the white- and red-hot parts of the carbon. Whether I will retain this measuring point in the future will depend on whether it can be discovered from which points on the carbon or the

arc emits the greatest amount of bacteria-killing rays. As long as one always maintains the same distance, it is only important that one measures from the same point in all experiments. This distance is checked before each series of experiments, and for this purpose I use a sheet metal plate on which each of the determining points is marked once and for all. If fresh coals are used, the lamp must first burn for about a quarter of an hour for the ring discussed to form

The entire sheet metal box is filled with the liquid through which the light is to be filtered, usually with freshly boiled distilled water. To keep the temperature constant, warm or cold water is passed through the spirally wound lead tubes (R); the water leaves the box again through the other end of the tube without coming into direct contact with the liquid in the box. In the center of the box, a paddle wheel (P) is mounted on a through shaft, which is kept in vigorous rotation by a small electric motor (2). To ensure that the water can be stirred as thoroughly as possible, the paddles are mounted obliquely on the axle, so that in addition to the rotating movement of the water, a powerful current perpendicular to it is obtained. The speed of the motor is regulated by switchable incandescent lamps

— The temperature of the water is read on the thermometer S; its container is protected from direct rays by a small screen. At T there is an opening for a thermometer with a blackened container, which is to be placed directly next to the culture, exposed to light. The entire inner side of the box, as well as the lead tubes, are matte black to protect the culture from reflected light.

At a certain distance behind the quartz window (at 00) is a metal backdrop into which a brass frame, supporting the culture apparatus by means of springs, can be inserted. In the following experiments, I used a "humid chamber" with a hanging drop as the culture apparatus; the cover plate is made of plane-parallel ground quartz, cut out perpendicular to the optical axis. The thickness of this covering quartz is 0.9 mm; after the culture drop is attached to its underside, the covering quartz is glued to the object glass; this has a spherical segment-shaped cutout, 1 mm deep, 14 mm in diameter, into which the curved surface of the culture drop thus projects freely. The distance between the front surface of the covering quartz and the back surface of the quartz window, or in other words: the thickness of the light-filtering liquid layer, can be varied as desired; In the experiments described below, I always used a distance of 25 mm. (In later versions of the apparatus, I varied the thickness of the water layer by securing the quartz window in a tube that could be adjusted by means of a thread.)

In the figure, at u, you can see a small lid which, moved by means of a small stem, can expose the quartz window to light and cover it again. NE is the lid of the box; it is attached in — such a way that, when open, it shields against the light, so that the culture apparatus can be removed and inserted without being exposed to light; of course, they must also be protected from light during transport to and from the box.

The advantages of this apparatus.

1. The optical conditions are simple If the lamp, as discussed, is maintained at a constant current and voltage, with the same type of carbon, without shifting the arc or the direction of the crater, the intensity of the light striking the front surface of the quartz window depends on the distance, the angle of radiation, and the angle of incidence; these three quantities are all precisely known. The refracting surfaces are approximately (see below) perpendicular to the direction of the rays used. The reflection and refraction are as simple and straightforward as possible, since between the light and the culture there is only a plane-parallel layer of distilled water, of known thickness, sandwiched between two plane-parallel polished quartz plates. The surface of the culture is also plane and perpendicular to the rays, being formed by the side of the drop—whether made of a solid or liquid medium—which touches the covering quartz. Because the back convex surface of the drop is concave to the light, the light has unhindered access to every single part of the drop. Only if the drop were curved to form more than a hemisphere would the reflection cause some parts of the interior of the drop to be in the dark; but it is very easy to make the drop flat, and if it is supported with a platinum loop of the appropriate size, it will naturally assume a suitable shape. The bouillon drop I used was 1.5 to 2 mm wide from side to side, and 0.05 to 0.15 mm deep from front to back.

Under these simple conditions, one can determine, both by calculation and by direct experiment, what percentage of the light used reaches the culture drop. I have not yet undertaken an exact determination of these conditions, simply because I have not had any use for them so far. I have only calculated a few limiting values to be on the safe side: The ray that deviates most from the incidence slot, which can be imagined under the given conditions, is obtained if we place two slides next to each other in the apparatus and if we have placed four drops on each of the two covering quartz crystals, and if the cultures are illuminated at the shortest distance from the light; I have chosen 280 mm as the shortest distance. The outermost point of the most practical drop then comes at most 18 mm to the side of the center line (i.e., the line connecting the center of the light ray will then be source and the center of the quartz window). The most deviating the one that, for example, B. from a point on the extreme right of the upper coal towards the extreme point of the leftmost culture drop. But even such an extreme ray deviates, where it hits the quartz window, only 5° 52' from the normal to the incidence. In addition, this ray, like its nearest neighbors, has only an extremely low luminous intensity because their angle of radiation is almost 90°. But even if one were to assume that some of the rays have an angle of incidence of approximately 6°, this plays only a negligible role in practice. According to Stolze (quoted by Eder), the light loss due to reflection from a flat glass plate at an angle of incidence of 0° is < 0.66%, at 5° it is 1.5%, and at 15° it is 3.4%. Thus, none of the rays used would have more than approximately 1.5%.

lose, the majority of them even less. I have not been able to find in the literature how the reflection from a quartz plate behaves, but I can casually assume that it does not behave significantly differently than from glass. With regard to visible rays, Mr. Absalon Larsen found through direct experiments that at the angle of incidence o, only about 0.35% is reflected from the quartz surface Reflection at the quartz-water interface (where the discussed "unfavorable" ray strikes at 3° 48'), water-quartz (4° 24'), and quartz-nutrient medium (3° 48') can certainly be neglected in practice because the difference between the refractive indices of these substances is so small. Within the nutrient medium itself, the most unfavorable ray will deviate only 4° 20' from the normal. During these various refractions (where the refractive indices for quartz, water, and nutrient medium are set at 1.54, 1.33, and 1.35), the most deviated ray will be 0.74 mm closer to the center line. I have already taken into account the resulting concentration of light, which, as can easily be demonstrated, occurs over the entire illuminated surface, when calculating the distance (p. 17).

While the luminous intensity suffers a slight attenuation due to reflection, it is, on the other hand, slightly amplified by a reflection from the rear surface of the nutrient drop, whereby a portion of the light passes through the drop twice. This amount of light will not be large, and in similar experiments it will be approximately the same each time.

The loss due to absorption is also very small. One usually wishes to have a certain kind of absorption, namely of a portion of the ultra-red heat-

rays, which are held back particularly by the water layer, and partly also by quartz. For the remaining rays, including ultraviolet rays, quartz and water are the two most permeable materials that can be considered; as far as certain invisible rays are concerned, this is already clear from my experiments with quartz discussed on page 6. For the visible spectral region, H. Rubens and E. Ashkinas state that quartz possesses "almost perfect" permeability, so that the absorption loss cannot be measured at all.

2. The luminous intensity can be graduated with precision. Since it is not possible to vary the intensity of the light source according to a sufficiently precise scale, and since the various methods of measuring light have all been partly cumbersome and inaccurate, and partly completely ineffective, when it comes to determining ultraviolet rays, the most accurate method, as far as I can see, for obtaining various specific light intensities is to use the lawful decrease in luminous intensity inversely proportional to the square of the distance.

Conversely, this device will contain a measuring device to determine the bactericidal radiation content of a light source (e.g., a light-collecting device). Such a measuring device is all the more necessary because we currently have little knowledge of which part of the ultraviolet rays has the most bactericidal effect, much less have we been able to measure their quantity. —

3. The light absorption of the culture medium is limited as much as possible by using it in very thin layers (0.05-0.15 mm) for subsequent tests. A preliminary determination

—

according to what Mr ABSALON LARSEN has done for me, absorbs both agar and broth in layers of a few millimeters about half of the silver chloride rays, and one can certainly expect that the absorb bacteria-killing rays at least as strongly The fact that absorption, on the other hand, is not a practical I conclude that the thickness of the drop plays a rôle in the very thin layers mentioned above: although in most of my experiments I intentionally placed a somewhat thicker drop next to a very thin one, I was unable to demonstrate a consistent difference in the results. At the limiting values, where the bacteria often grew in one of the (usually four) drops deposited on the same covering quartz, while the remaining drops remained sterile, the bacteria grew just as often in one of the thin drops as in one of the thick drops. Of course, the thickness of the drop cannot be entirely without influence; but I can say that it plays no role as long as the gradations of the illumination times are not made smaller than in the subsequent experiments. I hope to be able to demonstrate later how the exact limit for the largest permissible drop thickness can be determined by the apparatus itself.

This, incidentally, is not the only advantage of the hanging drop. Apart from the fact that, as discussed above, the side of the culture facing the light is made completely flat, it also ensures that oxygen has very easy access to the entire culture, as the hollowed space of the slide is many times larger than the culture drop, a circumstance to which one must attach all the greater importance, as several researchers have stated that they have obtained different results depending on whether the exposed test tubes, etc., were more or less highly charged with

filled with the nutrient fluid. A great advantage of the drops is the small space they take up; one can easily place, for example, four drops on the same covering quartz, and two such drops (each with four drops) can fit next to each other in the apparatus, or if each slide carries two hollow — ground glass sections, a total of 16 drops without any ray receiving a less favorable — direction than calculated above. If, on the other hand, larger culture vessels were used, a corresponding number of these would take up so much space if they were to be illuminated simultaneously that a possible oblique position of the crater would cause a very significant difference in the amount of light reaching each individual drop. Finally, the small size of the drop allows one to conveniently investigate the effect of a narrowly defined zone of a given light field, e.g., a specific region of a spectrum

The fact that all exposed bacteria are accessible to direct microscopic examination may also be important.

The possibility that drops placed on the same covering quartz infect each other cannot be completely ruled out, although a glance at the tables below will show that this, if it occurs at all, is certainly very rare. I have not yet seen a case where I suspected it had occurred. But to avoid such an objection, I have always placed only drops taken from the same culture next to each other. If one sees outgrowth in more than one drop, a skeptic could perhaps claim in an individual case that one drop had infected the others; but in one of the drops, he must admit, the bacteria have not all been killed. And no objection can be raised against the drops

that remain sterile after exposure to light (see, incidentally, "The Explanation of the Experiments," p. 78).

Before me, Pansini and, to some extent, Kruse used the drop method, both in experiments with sunlight and using cover glasses. I am only familiar with Pansini's experiments from a brief report; he is said to have found that anthrax bacilli are killed in 70 minutes. Kruse achieved similar results (summer sun, Naples); however, he only applied the method in a few experiments, which, incidentally, he describes so sketchily that I do not feel obliged to go into them in more detail

4. The temperature conditions are taken into account. Above all, it is important to ensure that the temperature of the nutrient medium does not rise so high that the death of the microbes could be due to the heat. The culture is cooled by being surrounded by water, which is kept in lively flowing motion by the motor. Since the covering quartz is thin and the quartz is also a relatively good heat conductor, and since the drop is very thin, the conditions are particularly favorable for keeping the culture at the same temperature as the surrounding water. To see to what extent this reasoning corresponds to the actual conditions, I conducted the following experiments:

The simplest, and actually convincing, way is to illuminate your own finger at the location of the culture. Even at the shortest distance from the light (28 cm), and even if the finger was blackened, if the motor is running at the appropriate speed, you feel no warmth in your finger other than that resulting from the temperature of the water

speaking, while outside the box, at the same distance, one feels vivid pain after less than a minute. For greater certainty, in very numerous experiments, carried out at very different water temperatures, I placed a thermometer with a sooted container through the opening T (see the figure) directly next to the culture. The temperature difference between this thermometer and the shaded one (S) never reached 14. Finally, the following experiments seem completely convincing to me: On the back of the covering quartz, directly next to or between the culture drops, I placed small cubes made of substances with different melting points (butter, Vaseline, and especially various paraffins with melting points of 41.5°, 45°, 50°). These can be illuminated for as long as desired, at a distance of 28 cm, without them melting, as long as the water temperature is kept below the melting point of the substance in question; If the temperature of the water is allowed to rise, the cubes do not melt until the shaded thermometer shows temperatures that are at most 1/20 below the actual melting point. Even when these substances are kneaded with soot, this ratio remains almost unchanged. In all experiments below 36.5°C, the covering quartz is adhered to the microscope slide by means of yellow Vaseline (mp 36.5°C); as soon as the water temperature exceeds 36.5°C, it melts immediately and the covering quartz sinks to the bottom; at all temperatures up to 36.5°C, the Vaseline shows no sign of melting, even after hours of illumination.

Of course, the effect of heat rays is not entirely excluded if the thickness of the water layer is only 25 mm and the distance 28 cm. But it is not the intention, at least for the time being, to completely exclude them.

conclude that it is probably most natural to begin the investigations with a light that contains all the elements, including the heat rays; only, it is necessary, by means of water and quartz, to eliminate such a large portion of the heat rays that the culture drop can be maintained at the temperature chosen for the individual experiment. In other words, it is not the heat rays as such that must be avoided, but rather an excessively high temperature of the culture fluid, and the tests discussed above prove that we have prevented such a situation.

For practical reasons, too, the effect of the heat rays must be studied within these limits; for should it turn out that they have a bactericidal effect, they could very well be used therapeutically because, as discussed, the skin nerves have no objection to illumination under these conditions

I do not limit myself to keeping this temperature so low that it cannot harm the bacteria; I also keep it constant in each series of experiments because it is quite probable a priori that the light effect will not be the same at all temperatures, which is also confirmed by my experiments (see p. 93).

5. Stirring by means of a paddle wheel achieves three things: First, it keeps the temperature constant everywhere in the box. Second, the experiments with paraffin cubes discussed above have shown that the temperature in the humid chamber cannot be kept the same as the temperature of the surrounding water if stirrers are not used. Third, this prevents dust particles and similar unavoidable impurities from settling on the

to fix covering quartz. A speck barely visible to the naked eye would otherwise suffice to provide a shadow for a few bacteria, which could later populate the entire drop, at least when using a liquid nutrient medium.

Precaution when using the apparatus.

The quartz plates must be completely clean. An almost invisible film of dirt is sufficient, as has been shown on many occasions (e.g., our experience with therapeutic light-collecting apparatus), to reduce the effective amount of light to an unexpected degree. The quartz window must therefore be carefully polished on both sides immediately before the start of the experiments, and during the experiments, one must continually pay attention to it, removing every speck of dust and the like using small, specially designed instruments (a fine brush for the outer side, a glove-leather buff for the inner side of the window). For experiments lasting only a few seconds, these manipulations must be performed before the culture is placed in the box; for longer experiments, it makes no difference if a speck of dust is brushed away with a quick movement. The same amount of effort must be applied to the covering quartz. Before the experiment, these are washed in spirit, carefully dried, and every visible speck of dust is removed with a brush. Afterwards, each one is individually wrapped in smooth paper and, like the corresponding microscope slides, sterilized at 140°C. After the culture drops have been deposited on the underside of the covering quartz using a platinum loop of a certain size,

are set, it is adhered to the slide using sterile petroleum jelly; if temperatures above 35°C are to be used, a layer of Unguentum cerae (Ph. dan.), which only melts at 58°C, is also placed around the edge of the covering quartz. Care must be taken to ensure that no trace of petroleum jelly gets on the front surface of the covering quartz, because even the thinnest layer can block the majority of the ultraviolet rays, as petroleum jelly is very strongly fluorescent

Another significant source of error can be the water in the box. You must use freshly boiled, distilled water; otherwise, it is difficult to prevent the formation of small air bubbles, which, among other things, settle on the covering quartz. A minimal air bubble is enough to protect a large number of bacteria from the light, and before I realized the significance of these bubbles, it was impossible for me to obtain consistent results. If you use a liquid other than distilled water, you must not forget that the absorption conditions are different. Even ordinary tap water absorbs the majority of ultraviolet rays. You must also avoid electrolytic effects as much as possible through careful varnishing so that no metal salts are formed

2) Experimental Protocol I.

Variations in the resistance of B. prodigiosus according to the age of the culture and the temperature of the nutrient medium.

In the following, I do not limit myself to reporting my results, but I reproduce my experimental protocol verbatim, even the unsuccessful experiments, because the development of the experimental method is not without a certain interest.

The following conditions are common to all experiments in this first protocol (series 1-36):

The lamp (shunt lamp from Siemens & Halske). Positive carbon 24 mm diameter, negative carbon 15 mm diameter, current 35 amperes. The rheostat available in experimental series 1-33 functioned somewhat poorly, so that the current could not be maintained exactly at 35; it was kept between 35 and 3534 A, on average at 35/3 If 35 A is noted in the experimental protocol, this margin is meant. If a larger fluctuation occurred now and then, it will always be explicitly noted. From series 34 onwards, a rheostat was used, which I had manufactured so that arc lamps could be switched on one after the other or several at the same time, in parallel with the main resistance, whereby the current intensity could easily be maintained so constant that the oscillations could hardly be seen on an ordinary ammeter. The voltage was kept as far as possible between 50 and 52 volts and is noted for each individual experiment. How great an influence on the amount of bactericidal rays

Variations in current and voltage within these limits must be left to later experiments. It is usually stated that the intensity of visible light increases somewhat more than proportionally to the current. According to the experiments of Absalon Larsen (see later), one can expect that a variation in current of 30 to 31 amperes corresponds approximately to a 5% increase in luminous intensity in the region of lines K and H. I myself obtained similar results through experiments with silver chloride paper. A large proportion of the small irregularities within the individual series of experiments could be plausibly explained by this source of error. But for now, it must be noted that, according to other experiments carried out at the Light Institute, the intensity of the bactericidal rays does not appear to increase proportionally to the rays acting on silver chloride.

The light filter always consisted of distilled water 25 mm thick (as well as the two quartz plates).

The test subject was always B. prodigiosus in pure culture. At appropriate intervals, I assured myself that the cultures were still pure. Both the cultures and the sterile nutrient medium were always kept in the dark; when they were taken out, I always avoided direct exposure to sunlight or arc light. After the illumination was complete, the culture apparatus was placed in the incubator, the temperature of which was 22°C in row 1-30, and always 25°C in the later rows, because it was impossible to maintain a constant temperature of 20°C in the hot summer months.

In all doubtful cases, the diagnosis of "growth" or "death" was confirmed by inoculation into fresh nutrient medium.

The nutrient medium was always the lightest possible, slightly alkaline veal broth, prepared according to the general procedure in Salomon's bacteriological technique. When salts or similar impurities began to separate, a new portion was prepared. The bacteria were cultivated in test cylinders of constant size and shape, each containing exactly 2 cm^3 of broth.

The distance of the light source from the front surface of the culture was always 280 mm. Since part of this distance is taken up by a 25 mm thick layer of water + 2.5 mm quartz, the light intensity, according to what was developed on page 17, would have corresponded to a distance of 273 mm without the use of such light-refracting media.

The time was measured using a chronograph that allowed readings of 1 second

Explanation of the tables: A Ampere, V = Volt, sec. the time the culture drop in question was exposed to light, given in seconds. O means that the culture was not illuminated at all, i.e., control experiment; the temperature indication in such a case means that the culture was exposed to the respective temperature in the box without illumination. Or 1 T., 2 T. indicates the number of hours, or days, that have passed individual 1 hour, or 2 hours, since illumination, at the time when the culture drop is examined. + means that the bacteria have grown diffusely throughout the drop, that the drop remains clear, i.e., without visible growth. s means that the bacteria have grown "scattered," o: they have grown only in individual, circumscribed parts of the drop (I will return to the explanation for this later). In rows 1-6, I did not distinguish between and s, and I am

I am also not sure that I defined "s" in the first 12 rows in the same way as later. If there are several +, or, or s in a column, this means that a corresponding number of separate drops were placed on the relevant covering quartz.

— I have used italics throughout the experimental protocol for those comments that I later added to the original text written during the experiments.

Rows 1-4.

(26/1.—3/2. 99.)

No.	Tp.	A	v.	Sek.	1 T.	2 T.	4T.	5T.
1	30°	34—35	50—52	300	—	+	+	+
2	"	35	51—53	420	—	+	+	+
3	"	"	51—53	660	—	—	?	+
4	"	"	52—54	900	—	?	+	+
5	"	—	—	0	+	+	+	+
1	30°	35	49—51	900	—	—	—	—
2	"	"	50—52	1200	?	+	+	+
3	"	"	50—52	1500	—	—	—	—
4	"	"	52—53	600	—	—	—	—
1	30°	34—36	51—55	3000	—	+	+	+
2	"	35	52—54	3300	—	—	—	—
1	30°	35	51—55	1800	—	—	—	—
2	"	"	"	2100	—	—	—	—

These preliminary experiments seem incomprehensible. Even 3000 seconds doesn't always seem sufficient. However, the 3000-second illuminated culture itself provides a clue to the right path; it turned out that a very thin layer of petrolatum was present on the coverslip. Perhaps the small air bubbles forming on the cover quartz also played a role.

Row 5. (8/2.99.)

All air bubbles are removed as soon as they form.

No.	Tp.	A	v.	Sek.	1 T.	2 T.	3 T.	4 T.
1	30°	34—36	49—51	480	—	—	—	—
2	"	35	50—52	600	—	+	+	+
3	"	"	52	660	—	—	—	—
4	"	"	51—52	720	—	—	—	—
5	"	"	52—54	900	—	—	—	—
6	"	"	49—53	1200	—	—	—	—
7	"	"	—	0	+	+	+	+
8	"	"	—	0	+	+	+	+
9	"	"	—	0	+	+	+	+

No. 2 grew in a manner we later call "dispersed." We see that after removing the air bubbles, the bacteria are killed in a shorter time than in row 1.

Row 6. (11/2.99.)

No.	Tp.	A	v.	Sek.	1 T.	2 T.	3 T.	4 T.	5 T.
1	30°	—	—	0	+	+	+	+	+
2	"	—	—	0	+	+	+	+	+
3	"	35	50—52	240	—	+	+	+	+
4	"	"	"	300	—	—	—	—	—
5	"	"	"	360	—	+	+	+	+
6	"	"	50—51	420	—	+	+	+	+
7	"	"	50—52	480	—	—	—	—	—

To completely avoid the formation of air bubbles, distilled water is used here (as in all subsequent experiments) immediately before the experiment. Continued cultivation reveals that the fully grown colonies are indeed Prodigiosus. Some are now killed in just 300 seconds or 5 minutes.

Series 7. (15/2. 99.)

The window is now (as always later) carefully cleaned immediately before the experiment with hydrochloric acid, spirit, and water and then polished.

No.	Tr.	A.	V.	Sec.	1 T.	2 T.	3 T.
1	30°	—	—	0	+	+	+
2	"	35.5	53—54	60	s	+	+
3	"	35	52—54	120	s	+	+
4	"	34—36	53—54	180	?	+	+
5	"	35	52—54	240	—	s	+
6	"	34—36	53—54	300	—	—	—
7	"	35	53—54	360	—	s	+
8	"	35	51—54	420	—	s	+
9	"	—	—	0	+	+	+

No. 6 The lamp regulated poorly.
No. 6 was sterile even after inoculation.

Row 8. (18/2.99)

No.	Tp.	A.	V.	Sec	1 T.	2 T.	3 T.	4 T.	10 T.
	30°		—	0	+	+			
2	"	—	—	0	+	+			
3	"	35	50	60	s	s			
4	"	"	50	120	?	s			
5	"	"	50—53	150	—	s			
6	"	"	51—52	180	—	s	+	+	+
7	"	?	?	?	—	s	+	+	
8	"	35	49—51	240	—	—	—	—	—
9	"	"	49—51	270	—	s			
10	"	"	48—52	300	?	s	+	+	

Series 9. (1/3. 99.)

No.	Tr.	A.	V.	Sec.	1 T.	2 T.	3 T.	5 T.
1	30°	35	50—51	60	?	s	+	+
2	"	33—36	"	120	—	—	—	—
3	"	35	"	180	s	s	s	s
4	"	"	50—53	240	—	s	+	+
5	"	"	50—52	300	s	s	s	s
6	"	"	"	120	—	s	s	s
7	"	"	49—52	180	—	s	s	s
8	"	"	50—52	240	—	s	s	s
9	"	"	50—51	120	—	s	s	s
10	"	"	"	180	s	s	s	+
11	"	"	49.5-52	240	—	—	+	+

Nos. 3, 5 and 11. By continued inoculation it is determined that it is truly Prodigiosus.

Since the drops have so far been taken from more or less old, strongly red cultures, one considers the possibility that the inconsistent results could be dependent on the pigment crumbling. Therefore, experiments are now being carried out with very young cultures; but because the age of the culture is not yet considered of great importance, experiments with different temperatures are being carried out at the same time. The exact age of the culture is also not noted.

Series 10. (9/3/99)

No.	Tr.	A.	V.	Sec.	1T.	2 T.	3 T.	4 T.	6 T.
1	10^0	—	—	0	+	+	+		
2	"	—	—	0	+	+	+		
3	"	—	—	0	+	+	+		
4	"	—	—	0	+	+	+		
5	"	34·5-35·5	49—53	300	—	—	—	—	—
6	"	35	49—52	360	—	—	—	—	—
7	"	"	48—52	420	—	—	—	—	
8	"	"	49—52	480	—	—	—	—	
9	"	"	47—51	540	—	—	—	—	
10	"	"	51—55	600	—	—	—		
11	"	"	49—51	720	—	—	—		
12	"	35—36	48—52	360	—	—	—		

Nos. 5 and 6 were found to be sterile by inoculation.
The drops were deposited from a very young culture.
In this series (as in all subsequent ones), the moist chambers are blindly removed from the row of finished preparations as a control, so that the order in which the drops were deposited has no influence; only then are they numbered and illuminated

Series 11. (17/3/99)

No.	Tr.	A.	V.	Sec.	1T.	2 T.	3 T.	4 T.
1	10^0	—	—	0	+	+	+	+
2	"	34·5-35·5	50—51	60	—	?	+	+
3	"	35—36	49—53	120	—	—	—	—
4	"	35	49—52	180	—	—	—	—
5	"	"08	(47)—54	240	—	—	—	—
6	"	35—36	47—54	300	—	—	—	—
7	"	35	50—56	360	—	—	—	—

The lamp regulates poorly.

From Nos. 3-7, inoculation with broth is carried out in the same glass; the same remained sterile

With rows 10 and 11, we have a completely new picture: consistent results and sterilization in less than 120 seconds. To see whether the reason for this could be that the temperature was 10, whereas in the earlier experiments it was 30, the following series of experiments is carried out:

Row 12. (21/3. 99.)

No.	Tp.	A	v.	Sek.	1 T.	2 T.	3T.
1	—	—	—	0	+	+	+
2	—	—	—	0	+	+	+
3	20°	35	51—53	180	—	—	—
4	"	"	53—55	120	—	—	—
5	10°	35	50—53	180	—	—	—
6	"	"	50—52	120	—	—	—
7	"	"	50—52	90	—	—	—
8	"	"	50—51	60	—	—	—
9	40°	35	50—52	180	—	—	—
10	"	"	50—52	120	"	"	"
11	30°	35	49—52	180	—	—	—
12	"	"	49—52	120	—	—	—

No. 10 failed because the covering quartz slipped down because the petroleum jelly melted; it got stuck in No. 9, although the Vaseline melted immediately here too.

Nos. 7 and 8 were inoculated in broth; this remained sterile.

According to this, it is hardly the temperature differences that were decisive in rows 10 and 11. Rather, one had to try to determine the influence of the age of the culture.

Row 13. (28/3.99.)

No.	Tp.	A	v.	Sek.	1 T.	2 T.	3 T.	4T.	
1	—	—	—	0	+	+	+	+	Old approx. 6 Hours
2	—	—	—	0	+	+	+	+	
3	20°	35	51	60	—	+	+	+	
4	"	"	50—51	120	—	—	—	—	
	"	"	50—52	180	—	—	—	—	
6	—	—	—	0	+	+	+	+	Old approx. 30 Hours
7	20°	35	49—51	60	—	s	s	s	
8	"	"	50—53	120	—	s	s	s	
9	"	"	49—53	180	—	—	—	—	
10	"	"	51—52	60	?	+	+	+	Old approx. 54 Hours
11	"	"	50—53	180	?	+	+	+	
12	"	"	49—53	360	—	—	—	—	

From No. 12 is vaccinated in broth; this remains sterile.

No. 1-5: The drops were from a 6-hour-old, still clear broth culture.

No. 6-9: Ditto from a 30-hour-old, unclear bouillon,

No. 10-12: Ditto from a 54 hour very unclear bouillon culture.

So age seems to be important. The 6 hour old culture was killed between 60 and 120 seconds, while the 54 hour old took between 180 and 360 seconds,

Series 14. (24.99.)

No.	Tr.	A.	V.	Sec.	IT.	2 T.	3 T.	4 T.	
1	—	—	—	0	?	+	+	+	Age approx. 6 hours
2	—	—	—	0	?	+	+	+	
3	30°	35	50—52	20	—	—	—	—	
4	"	"	52	40	—	—	—	—	
5	"	"	51	60	—	—	—	—	
6	"	"	51—52	80	—	—	—	—	
7	"	"	51—52	100	—	—	—	—	
8	"	"	51—52	120	—	—	—	—	
9	"	"	51—53	140	—	—	—	—	
10	30°	35	51—52	100	s	+	+	+	Age approx. 56 hours
11	"	"	50—53	140	—	—	—	—	
12	"	"	50—53	180	—	s	+	+	
13	"	"	49—51	220	—	—	s	+	
14	"	"	50—53	260	—	—	—	—	
15	"	"	49—52	300	—	—	—	—	
16	"	"	48—53	340	—	—	—	—	

Nos. 1-9 separated from approximately 6-hour-old, still clear broth culture.

Nos. 10-16 from approximately 56-hour-old, very unclear broth culture

The influence of age again seems unmistakable; closer inspection, however, shows that this series is only slightly convincing in this respect, because the 6-hour-old culture was (for an unknown reason) already very weak before illumination, since the control drops showed hardly any visible growth even after 24 hours, and because the culture was sterile after just 20 seconds of illumination, which is quite abnormal (cf., for example, the following series).

Series 15. (4.99.)

No.	Tp.	A.	V	Sec.	IT.	2 T.	3 T.	4 T.
1	—	—	—	0	+	+	+	+
2	—	—	—	0	+	+	+	+
3	—	—	—	0	+	+	+	+
4	30°	35	50	5	+	+	+	+
5	29°	"	50	10	—	+	+	+
6	"	"	51	15	—	s	+	+
7	"	"	51	20	—	+	+	+
8	"	"	51—52	40	—	s	+	+
9	"	"	51—52	60	—	+	+	+
10	20°	35	50	2	+	+	+	+
11	"	"	50	5	+	+	+	+
12	"	"	51	10	+	+	+	+
13	"	"	50	15	+	+	+	+
14	"	"	50	20	+	+	+	+
15	"	"	50—51	40	—	+	+	+
16	"	"	51	60	—	—	—	—

Nos. 1-16 from a 6-hour-old broth culture.

In this series, as in most of the previous series, the duration of illumination was unfortunate, so that the killing limit is not clearly visible. From the next series of experiments onwards, based on the experiences gained in series 1-15, I have been more fortunate in this respect

Series 16. (15/4.99.)

No.	Tr.	A.	V.	Sec.	1 T.	2 T.	3 T.	5 T.	6 T.	
1	30°	34	50	5	—	?	+	+	+	Age approx. 8 hours.
2	"	35	50	10	—	?	+	+	+	
3	"	"	51	15	—	—	+	+	+	
4	"	"	50	20	—	—	+	+	+	
5	"	"	51	25	—	—	+	+	+	
6	"	"	50	30	—	—	—	—	—	
7	"	"	50—51	60	—	—	s	s	+	
8	"	"	50—52	120	—	—	—	—	—	
9	"	"	50—52	180	—	—	—	—	—	
10	"	"	50—52	240	—	—	—	—	—	
11	"	"	49—53	300	—	—	—	—	—	
12	20°	35	50	5	—	—	?	?	+	
13	"	"	50	10	—	—	+	+	+	
14	"	"	50	15	—	—	+	+	+	
15	"	"	51	20	—	—	—	—	—	
16	"	"	50	25	—	—	s	s	+	
17	"	"	50—51	30	—	—	—	—	—	
18	"	"	51—52	60	—	—	s	+	+	
19	"	"	50—51	120	—	—	—	—	—	
20	"	"	48—51	180	—	—	—	—	—	
21	"	"	48—51	240	—	—	—	—	—	
22	"	"	47—51	300	—	—	—	—	—	
23	—	—	—	0	+	+	+	+	+	
24	—	—	—	0	+	+	+	+	+	
25	—	—	—	0	+	+	+	+	+	

Nos. 1-25 from approximately 8-hour-old, clearly unclear culture after dilution with equal parts of broth, so that the mixture from which the drops were taken was almost completely clear. Since I did not note how long elapsed between dilution and illumination, it is unclear whether the culture should be assumed to be 8 hours old or completely fresh.

Series 17. (28/4.99.)

No.	Tr.	A.	V.	Sec.	1 T.	2 T.	3 T.	
1	30°	35	51	5	—	?	+	Age approx. 8.5 hours.
2	"	"	51	10	—	—	—	
3	"	"	50—51	20	?	+	+	
4	"	"	51	30	—	+	+	
5	"	"	51—52	40	—	+	+	
6	"	"	50	50	—	+	+	
7	"	"	50—51	60	—	+	+	
8	"	"	49—51	120	—	—	—	
9	25°	35	51	5	?	+	+	
10	"	"	51	10	?	+	+	
11	"	"	51	20	—	+	+	
12	"	"	51	30	s	+	+	
13	"	"	50	40	—	+	+	
14	"	"	51	50	s	+	+	
15	"	"	50—51	60	—	+	+	
16	"	"	49—51	120	—	—	—	
17	35°	35	50	5	+	+	+	
18	"	"	50	10	+	+	+	
19	"	"	50	20	+	+	+	
20	"	"	50—51	30	—	+	+	
21	"	"	50	40	s	+	+	
22	"	"	50	50	s	+	+	
23	"	"	50—51	60	s	+	+	
24	—	—	—	0	+	+	+	
25	—	—	—	0	+	+	+	

Nos. 1-25: From 24-hour-old culture, 8 and 9 hours before the start of the experiments, two platinum loops (otherwise only r) are inoculated into 2 cm³ of sterile broth; the drops are taken from this immediately before the start of the experiments.

Nos. 8 and 16 are inoculated with sterile broth on the 3rd day; this remains sterile

Series 18. (2/5.99.)

No.	Tp.	A.	V.	Sec.	14 hrs.	22 hrs.	30 hrs.	4 t.	5 t.	
1	30°	—	—	0	+	+	+	+	+	Age 7 hours.
2	"	35	50	1	+	+	+	+	+	
3	"	"	50	10	—	s	s	+	+	
4	"	"	52	20	—	s	s	s	s	
5	"	"	51—52	40	—	—	s	s	s	
6	"	"	51—52	60	—	—	?	?	+	
7	"	"	50—52	90	—	—	s	s	s	
8	"	"	49—52	120	—	—	—	—	—	
9	"	"	48—51	150	—	—	—	s	s	
10	"	35—36	47—51	180	—	—	—	—	—	
11	30°	—	—	0	+	+	+	+	+	Age 5 hours.
12	"	—	—	0	+	+	+	+	+	
13	"	35	50	ca. 0.1	+	+	+	+	+	
14	"	"	50	1	+	+	+	+	+	
15	"	"	50	5	—	+	+	+	+	
16	"	"	50	10	—	+	+	+	+	
17	"	"	50—51	20	—	+	+	+	+	
18	"	"	50	40	—	—	—	—	—	
19	"	"	50—52	60	—	s	+	+	+	
20	"	"	50—51	90	—	—	—	—	—	
21	"	"	49—52	120	—	—	—	—	—	
22	"	"	48—51	150	—	—	—	—	—	
23	"	"	50—53	180	—	—	—	—	—	

Nos. 1-10 from a culture started at 1:30 a.m., Nos. 11-23 at 4:00 a.m. Illumination began at 8:30 a.m., completed at 9:30 a.m. The sequence of experiments: 1, 2, 3, 11, 12, 13, 14, 15, 4, 17, 5, 18, etc. Both cultures are sown from one and the same culture; this was 24 hours old at the time. Thermostat 220.

Culture 1-10 is therefore just over 7 hours old, culture 11-23 about 5 hours old. Nos. 8, 10, 20-23 are inoculated into sterile broth on the 5th day; this remained sterile

Series 19. (6/5.99.)

No.	Tp.	A.	V.	Sec.	16 hrs.	22 hrs.	2 t.	
1	30°	35	50	1	+	+	+	Dilution $\frac{10}{2\ cm^3}$
2	"	"	50	2	+	+	+	
3	"	"	51	3	+	+	+	
4	"	"	52	4	+	+	+	
5	"	"	50	5	+	+	+	
6	"	"	50	60	?	+	+	
7	"	"	51—52	120	—	+	+	
8	"	"	50—51	180	—	+	+	
9	30°	35	50	1	+	+	+	Dilution 30 2 cm³
10	"	"	50	2	+	+	+	
11	"	"	51	4	+	+	+	
12	"	"	50	5	+	+	+	
13	"	"	52	60	+	+	+	
14	"	"	51—52	120	—	+	+	
15	"	"	50—52	180	—	—	—	
16	30°	35	50	1	+	+	+	12 O Dilution 2 cm³
17	"	"	50	2	+	+	+	
18	"	"	51	3	+	+	+	
19	"	"	51	4	+	+	+	
20	"	"	50	5	?	+	+	
21	"	"	50—52	60	—	+	+	
22	"	"	50—51	120	—	+	+	
23	"	"	50—51	185	—	—	—	
24	30°	—	—	0	+	+	+	
25	"	—	—	0	+	+	+	

No. 15 appears sterile even after inoculation. Nos. 1-8: 1 loop from an eight-day culture, which had already begun to turn red on the surface (room temp.), is transferred to 2 cm³ of sterile broth, from which, after shaking, the drops are immediately settled and illuminated. Nos. 9-15: 3 loops, incidentally ditto. — Nos. 16-25: 12 loops, incidentally ditto. Nos. 24-25 are placed for 3 minutes in 300 ml of water without illumination. Experimental order: 1, 9, 16, 2, 10, 17, etc. The safe killing limit was not reached. Finsen,

Medical Light Institute.

Series 20. (14/5.99.)

No.	Tr.	A.	V.	Sec.	14 hrs.	St. 14	St. 19	St. 24	44 hrs.	3 T.	5 T.	
1	30°	—	—	0	+	+	+	+	+	+		2 hours.
2	"	35	50	10	+	+	+	+	+	+		
3	"	"	50	30	+	+	+	+	+	+		
4	"	"	50—51	60	—	s	s	+	+	+		
5	"	"	50—51	120	—	—	—	—	—	—		
6	"	"	49—52	180	—	—	—	—	—	—		
7	30°	—	—	0	+	+	+	+	+	+		6 hours.
8	"	35	50	10	+	+	+	+	+	+		
9	"	"	51—52	30	?	+	+	+	+	+		
10	"	"	51—53	60	—	?	+	+	+	+		
11	"	"	50—53	120	—	—	—	—	—	—		
12	"	"	50—52	180	—	—	—	—	—	—		
13	30°	—	—	0	+	+	+	+	+	+		1 to 2 months.
14	"	35	50	10	+	+	+	+	+	+		
15	"	"	51—52	30	+	+	+	+	+	+		
16	"	"	51—53	60	—	+	+	+	+	+		
17	"	"	50—53	120	—	—	—	+	+	+		
18	"	"	50—52	180	—	—	—	+	+	+		
19	"	"	47—50	240	—	—	—	—	—	—		
20	"	"	48—51	300	—	—	—	—	—	—		
21	"	"	49—52	360	—	—	—	—	—	—		

Nos. 1-6: Approx. 2 tubes of old culture, sown from 24 tubes of old culture (2 loops). Clear at the beginning of the experiments.

Nos. 7-12: Approx. 6 tubes of old culture, 2 loops sown from the same culture as 1-6. Slightly cloudy at the beginning of the experiments.

Nos. 13-21: From a 1- to 2-month-old culture, which was bright red with sediment, above which a clear liquid; the latter was decanted and the sediment was transferred to 2 cm³ of sterile broth, which did not appear noticeably cloudy afterwards; the drops were taken from this.

8-12 and 14-21 were illuminated in pairs next to each other (8 next to 14, 9 next to 15, 10 next to 16, etc.).

In the following series of experiments (Series 21), the investigation into the influence of the age of the culture is continued by illuminating cultures with ages of 4-5 days, 11 hours, and 4 hours; and the investigation into the influence of the number of bacteria per unit volume, begun in Series 19, is continued. One could not, in fact, rule out a priori the possibility that the greater resistance of older cultures might be due to the fact that the bacteria in these were so numerous that they shaded each other. Two dilutions of the same culture were therefore prepared, so that one (Nos. 20-24) had to contain approximately 25 times as many bacteria per cubic millimeter as the other (Nos. 15-19). Furthermore, the two older cultures (Nos. 1-14) were diluted so strongly that they were completely clear to the naked eye appeared.

From row 21 onwards, several drops of equal value are placed side by side on the same covering quartz

can be screwed into the center of the ring that supports the apparatus.

The reason for such a cursory discussion of these investigations is that the Light Institute has recently been working diligently on new lamps with various types of electrodes. These lamps initially seemed to promise much, but did not live up to expectations. They have since taught us that more precise investigations into the ability of individual types of rays to penetrate tissue are necessary, and that there is little point in continuing to work on lamps until this question is completely clarified. In any case, all probability indicates that the future will bring better lamps, since the lamps currently in use are constructed only for the purpose of illumination, but not with the aim of causing inflammation and killing bacteria. Once it becomes clear to the experts in this field that they must construct something new for medical use, progress will surely follow

The second way to improve the method is to improve the apparatus. I have said a lot about this previously and will therefore be brief. Although the forms we currently use have emerged from the most careful investigations, it would be presumptuous to believe that they could not be improved in some respects.

--both the solar apparatus, the electrical collecting apparatus, and the printing apparatus, but what these improvements should consist of is not so easy to say at the moment. One of the most natural improvements, on which we have been working for some time, would be to treat a larger area at once, that is to say

to arrange the apparatus and lamps so that the light spots become larger without reducing the intensity of the light. With the usual apparatus with lenses of 7 cm diameter, one would have a spot of 7 cm in diameter, instead of the current one of 1/2 cm Diameter, if one were to place a flat plate of rock crystal in the lowest part of the tube instead of a convex lens. To achieve the same effect, the intensity of the light must, of course, be significantly increased at the same time. Such an enlargement of the light spot would be very advantageous for widespread cases, but unnecessary for less widespread ones. We will therefore probably have apparatuses with light spots of different sizes in the future, so that, as we have already arranged, one has light spots of different intensities

very practical improvement was recently made by A Dr. Reyn. Since the lens closest to the light often cracks, Dr. Reyn came up with the idea of cooling it with water. This is done by placing a flat rock crystal plate 2 cm in front of the uppermost lens. In the space created by this, there is distilled water, which is constantly cooled by a water stream circulating around it. This prevents the precious lenses from cracking, but also brings the entire apparatus closer to the light, and this can thus be better utilized.

The Application of the Method in Practice.

While I have dealt exclusively with the physical part of the method in the previous section,

Series 22. ($^{27}/_{5}$. 99.)

No.	Tr.	A.	V.	Sec.	12 hrs.	19 hrs.	25 hrs.	36 hrs.	44 hrs.	66 hrs.	80 hrs.	90 hrs.	Sec.	
1	15°	35	49	30	— —	s s s	s s s	s s s	s s s	s s s	s s s	s s s	30	15° Age approx. 6 hours.
2	"	"	52	40	— —	s —	s s s	s s s	s s s	+ +	+ +	+ +	40	
3	"	"	51	50	— —	— —	s s s	s s s	s s s	+ +	+ +	+ +	50	
4	"	35 (38)	53 (49)	60	— —	— —	— —	— —	— —	— —	— —	— —	60	
5	"	35	51—52	70	— —	— —	— —	— s	— s	— +	— +	— +	70	
6	"	"	52—53	80	— —	— ?	s —	s —	s —	+ —	+ —	+ —	80	
7	"	"	52—53	90	— —	— —	— —	— —	— —	— —	— —	— —	90	
8	"	"	51 53	100	— —	— —	s s	s s	s s	+ +	+ +	+ +	100	
9	"	"	50—52	110	— —	— —	— s	— s	— s	— +	— +	— +	110	
10	"	"	50—53	120	— —	— —	— —	— —	— —	— —	— —	— —	120	
11	"	"	51—53	135	— —	— —	— —	— —	— —	— —	— —	— —	135	
12	"	"	40—51	150	— —	— —	— —	— —	— —	— —	— —	— —	150	
13	35°	35	51	30	— —	s s	s s s	s s s	s s s	s s s	s s s	s s s	30	35° Age approx. 6 hours,
14	"	"	50	40	— —	— —	— —	— —	— —	— —	— —	— —	40	
15	"	"	51	50	— —	— —	— —	— —	— —	— —	— —	— —	50	
16	"	"	50—51	60	— —	— —	— —	— —	— —	— —	— —	— —	60	
17	"	"	50—51	70	— —	— —	— —	— —	— —	— —	— —	— —	70	
18	"	"	50—51	80	— —	— —	s —	s —	s —	s —	s —	s —	80	
19	"	"	49—51	90	— —	— —	— —	— —	— —	— —	— —	— —	90	
20	"	"	50—52	100	— —	— —	— —	— —	— —	— —	— —	— —	100	
21	"	"	50—53	110	— —	— —	— —	— —	— —	— —	— —	— —	110	
22	"	"	50—52	120	— —	— —	— —	— —	— —	— —	— —	— —	120	
23	"	"	51—52	135	— —	— —	s —	s —	s —	+ —	+ —	+ —	135	
24	"	"	51—53	150	— —	— —	— —	— —	— —	— —	— —	— —	150	
25	35°	—	—	0	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	0	

No. 4. In the last 5 seconds, 38 A. and 49 V.

Nos. 1-25: From 6 s of old, just cloudy broth culture, 1 loop is sown in 2.0 sterile broth 6 s before the start of the experiments; this broth is placed at 220. From this 6-hour-old culture, 4 drops are placed on each cover quartz, with the exception of 1 and 13, where only 3 are deposited.

Nos. 18 and 22 were clearly red only after 90 hours

Row 23.

(6/7. 99.)

No.	Tp.	A	v.	Sek.	11 St.	17 St.	20 St.	23 St.	35 St.	42 St.	47 St.	3T.	4T.	5 T.	Sek.	
1	18°	35	52	30	— — — —	— s — —	— s — —	s s — s	s s s s	s s s s	s s s s	s s s s	s s s s	s s s s	30	180. Age approx. 5 1/4 years.
2	19°	"	52	40	— — — —	— — — —	— — — —	— — s —	— s — s	— s — s	— s — s	— s — s	— s — s	— + + +	40	
3	6,50 p.m	"	50—52	50	— — — —	— — — —	— — s —	s — — s	s s s —	s s s —	s s s —	s s s —	s s s —	s s s s	50	
4	18°	"	52—54	60	— — — —	— — — —	— — — —	— — — —	— — s —	— — s —	— — s —	— — s —	— — s —	— — s —	60	
5	"	"	50—51	70	— — — —	— — — —	— — — —	— s — —	— s — —	— s — —	— s — —	— s — —	— s — —	— s — —	70	
6	"	"	50—51	80	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — s	— — — s	80	
7	"	"	51	90	— — — —	— — — —	— — — —	— — — —	— — s —	— — s —	— — s —	— — s —	— — s —	— — s —	90	
8	"	"	51—52	100	— — — —	— — — —	— — — —	— s — —	— s — —	— s — —	— s — —	— s — —	— s — —	— s — —	100	
9	"	"	51	110	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	110	
10	"	"	50—51	120	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	120	
11	"	"	51—52	150	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	150	
12	36°	"	50	20	— — — —	s — — —	s — — —	s s s s	s s s s	s s s s	s s s s	s s s s	s s s s	s s s s	20	36°. Age approx. 5 3/4 hours.
13	36,5°	"	50—51	30	— — — —	s — — —	s — — —	s s s —	s s s —	s s s —	s s s —	s s s —	s s s —	s s s —	30	
14	"	"	50—51	40	— — — —	— — — —	— — — —	— — — —	— — — —	s — — —	s — — —	s — — —	s — — —	s — — —	40	
15	36°	"	51	50	— — — —	— — — —	— — — —	— — — —	— — — —	— — — s	— — — s	— — — s	— — — s	— — — s	50	
16	36,5°	"	51	60	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	60	
17	36°	"	51—53	70	— — — —	— — — —	— — — —	— — — —	— — s —	s — s —	s — s —	s — s —	s — s —	s — s —	70	
18	"	"	51—52	80	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	s — — —	s — — —	s — — —	s — — —	80	
19	"	"	50—54	90	— — — —	— — — —	— — — —	— — — —	— — — —	— — — s	— — — s	— s — s	— s — s	— s — s	90	
20	"	"	50—54	100	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	100	
21	"	"	50—53	110	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	110	
22	"	"	50—54	120	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	120	
23	"	—	—	0	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + —	+ + + +	+ + + +	0	

Five hours before the start of the experiment, a loop of a 24-hour-old broth culture is sown in 2.0 broth; this latter culture, from which the drops are deposited immediately before the experiment, has been kept at 28°C (i.e., room temperature). The illumination began at 8:45°C, ended at 9:45°C, and was carried out in numerical order (12-23 being half to a full hour older than 1-11 at the moment they were illuminated).

No. 23 was placed in water at 360°C for 30 seconds without illumination. The 4 drops on each cover quartz.
temperature could only be brought slightly below 180°C without damaging the quartz. window was dewed due to the humidity of the atmosphere.

Series 24. (10/7. 99.)

No.	Tr.	A.	V.	Sec.	11 h.	17 h.	23 h.	38 h.	41 h.	45 h.	65 h.	Sec.	
1	16.5°	35	50	1	− − − −	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	1	16° Age approx. 3 hours.
2	"	"	51	2	− − − −	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	2	
3	"	"	50	3	− − − −	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	3	
4	"	"	50	5	− − − −	− − − −	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	5	
5	"	"	51	7	− − − −	− − − −	? ? + +	+ + + +	+ + + +	+ + + +	+ + + +	7	
6	"	35—36.5	50—51	9	− − − −	− − − −	− − + −	+ + + +	+ + + +	+ + + +	+ + + +	9	
7	"	35	51	11	− − − −	− − − −	− − ? ?	− − + +	+ − + +	+ − + +	+ − + +	11	
8	"	"	51	13	− − − −	− − − −	− − ? ?	s ? + +	s − + +	s + + +	+ + + +	13	
9	"	"	50	15	− − − −	− − − −	− − + ?	? − + s	+ − + s	+ − + s	+ − + +	15	
10	"	"	51—53	50	− − − −	− − − −	− − − −	− + + −	− + + −	− + + −	− + + −	50	
11	"	"	51	60	− − − −	− − − −	− − − −	? − − −	+ − − −	+ − ? −	+ − + −	60	
12	"	"	49—52	70	− − − −	− − − −	− − − −	− − − −	− − − −	− − − −	− − − −	70	
13	36°	35	50	1	− − − −	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	1	360 Age approx. 3.5 hours.
14	"	"	52	2	− − − −	? ? s s	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	2	
15	"	"	51	3	− − − −	? ? ? ?	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	3	
16	"	"	51	5	− − − −	− − − −	+ + ? +	+ + s +	+ + s +	+ + s +	+ + s +	5	
17	"	35—34	53	7	− − − −	− − − −	+ ? + +	+ s + +	+ s + +	+ s + +	+ s + +	7	
18	"	35	51	9	− − − −	− − − −	? ? ? ?	+ + s +	+ + s +	+ + + +	+ + + +	9	
19	"	"	51	11	− − − −	− − − −	− − − −	+ + + −	+ + + −	+ + + −	+ + + −	11	
20	"	"	51	13	− − − −	− − − −	− + − −	− + − +	+ + − +	+ + − +	+ + − +	13	
21	"	"	50	15	− − − −	− − − −	− + − −	− + s −	− + s −	− + s −	− + + −	15	
22	"	"	51	50	− − − −	− − − −	− − − −	− s − −	− s − −	− + − −	− + − −	50	
23	"	"	51	60	− − − −	− − − −	− − − −	− − − −	− − − −	− − − −	− − − −	60	
24	"	34—35	51—53	70	− − − −	− − − −	− − − −	− − − −	− − − −	− − − −	− − − −	70	
25	36°	—	—	0	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	0	

Nos. 1-25: From 24 pcs. of old broth culture, a loop is sown in 2.0 broth 3 pcs. before the start of the experiments.

4 drops on each quartz.
After illumination, the drops are placed in an unheated thermostat

Series 25 (contaminated culture). (12/7/99)

No.	Th.	A.	V.	Sec.	13 h.	17 h.	22 h.	37 h.	39 h.	46 h.	3 T.	4 T.	Sec.	
1	36°	35	50—51	20	— — — —	? — s —	s — s s	s — s s	s — s s	+ — + s	+ — + s	+ — + s	20	36° Age 3.5 Hours.
2	"	"	51	30	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	30	
3	"	"	50	40	— — — —	— — — —	— — — —	+ s — —	+ s — —	+ s — —	+ s — —	+ s — —	40	
4	"	"	50	50	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	50	
5	"	"	51—52	60	— — — —	— — — —	— — — —	— — — +	— — — +	— — — +	— — — +	— — — +	60	
6	"	"	51—52	70	— — — —	— — — —	— — — —	— — — +	— — — +	— — — +	— — — +	— — — +	70	
7	"	"	50—51	80	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	80	
8	"	"	51—53	90	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	90	
9	"	"	51—53	100	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	100	
10	"	"	51—53	110	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	110	
11	26°	35	50	20	— — — —	+ ? ? —	+ + + —	+ + + —	+ + + —	+ + + —	+ + + —	+ + + —	20	26° Age 4 Hours.
12	"	"	52	30	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	30	
13	"	"	53	40	— — — —	— — — —	— — — —	+ — — —	+ — — —	+ + — —	+ + — —	+ + — —	40	
14	"	"	51—52	50	— — — —	— — — —	— — — —	— s — —	— + — —	— + — —	— + — —	— + — —	50	
15	"	"	51—53	60	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	60	
16	"	"	50—53	70	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	70	
17	"	"	50—52	80	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	80	16° Age 5 Hours
18	"	"	50—52	90	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	90	
19	"	"	51—52	100	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	100	
20	"	"	52—53	110	— — — —	— — — —	— — — —	— — — —	— — + —	— — + —	— — + —	— — + —	110	
21	16.5°	35	51—53	20	— — — —	— — + —	— — + —	— — + —	— — + —	— — + —	— — + —	— — + —	20	
22	"	"	50—51	30	— — — —	— — — —	— — — —	— — s —	— — + —	— — + —	— — + —	— — + —	30	
23	"	"	52	40	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	40	
24	"	"	50	50	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	50	
25	"	"	50—51	60	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	60	
26	"	"	50—51	70	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	70	
27	"	"	50—52	80	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	80	
28	"	"	49—52	90	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	90	
29	"	"	50	100	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	100	
30	"	"	50—51	110	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	110	
31	36°	—	—	0	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	0	

Nos. 1-31: From 28 s. of old broth culture, one loop is sown in 2.0 s. of broth at 6 o'clock (i.e., 3.5 hours before the start of the experiments), from which the drops, 4 on each quartz, are deposited at 9-9.12: First, preparation 1, then 31, then 2, then 30, etc., are prepared. Illumination in numerical order, beginning at 9.5, ending at 11 o'clock.

Age, therefore, 3.5-5 s. No. 3: The attack in the two drops is caused by contamination by means of a small cotton thread. No. 2: Inoculation of the drops confirms their sterility

Nos. 5, 6, and 20 are inoculated with broth in a test tube; the culture that subsequently emerges shows, in addition to Prodigiosus, a foreign bacillus in all three cases. The remaining drops were discarded at this point

Row 26. (14/7.99.)

64 drops were deposited, which, with the exception of 4 control drops, were illuminated in 10-20 seconds. All remained sterile, and it turned out that the drops had been taken from sterile broth by mistake.

Row 27. (7/7. 99.)

No.	Tr.	A.	V.	Sec.	14 h.	20 h.	40 h.	3 d.	4 t.	5 t.	Sec.	
1	30°	35—36	51—52	30	s +	s +	s +	+ +	+ +	+ +	30	A 1 Age 13 3/4 hours.
2	"	35	52—53	60	— —	s —	+ +	+ +	+ +	+ +	60	
3	"	"	50—52	120	— —	+ s	+ +	+ +	+ +	+ +	120	
4	"	"	50—54	180	— —	— s	— +	— +	— +	— +	180	
5	"	"	50—54	240	— —	s —	+ —	+ —	+ —	+ —	240	
6	"	"	50—54	360	— —	— —	— —	— —	— —	— —	300	
7	30°	—	—	0	+ +	+ +	+ +	+ +	+ +	+ +	0	B Age 614 hours.
8	"	35—36	51—52	30	— —	s s	s s	s s	s s	s s	30	
9	"	35	52—53	60	— —	— s	— s	— s	— s	— s	60	
10	"	"	50—54	90	— —	— —	— s	— s	— s	— s	90	
11	"	"	50—52	120	— —	— —	— —	— —	— —	— —	120	
12	"	"	50—54	180	— —	— —	— —	— —	— —	— —	180	
13	30°	—	—	0	+ +	+ +	+ +	+ +	+ +	+ +	0	C Age 4 hours.
14	"	35	51	30	— —	s —	s —	s —	s —	s —	30	
15	"	35·5	50—53	45	— —	— s	— s	— s	— s	— s	45	
16	"	35	51—52	60	— —	— —	— —	— —	— —	— —	60	
17	"	"	50—54	90	— —	— —	— —	— —	— —	— —	90	
18	"	"	52—53	120	— —	— —	— —	— —	— —	— —	120	
19	"	35—36	50—53	150	— —	— —	— —	— —	— —	— —	150	

No. 1-19: From a completely red culture, started on July 14, one loopful in 2.0 broth is inoculated on July 16 at 6:00 p.m. From this, one loopful in 2.0 broth is inoculated this morning at 8:00 a.m., since a narrow red border is already visible on the surface A) inoculated. At 3.5 p.m., 2 loops of A were inoculated into 2.0 broth (Glass B), and at 6.4 p.m., 2 loops of A were inoculated into 2.0 broth (Glass C). (The room temperature at 7 p.m. was still 26°C.)

Drops of B and C are added between 8.5 and 9 p.m. to Nos. 7-12 and 13-19. At 9.5 p.m., 0.06 cm³ of A is transferred into 2.0 broth, which then appears unchanged and clear (Glass A1). (A itself had long since become cloudy.) Nos. 1-6 are added from A1. Illumination begins at 9.30 a.m. and ends at 10.30-

Order of illumination (2 at a time): (1, 8), (2, 9), (3, 11), (10, 17), (4, 12), 5, 6, 14, 16, 18, 15, 19. The age of A1, when illuminated, is therefore 13.5-14 hours, of B 6-6.5 hours, of C 3.4-4.5 hours.

The numbering order of Nos. 14-19 is not entirely certain, as some may have been swapped during the second viewing

Series 28. (20/7.99.)

No.	Tp.	A.	V.	Sec.	17 St.	40 St.	3 T.	4 T.	6 T.	
1	30°	—	—	0	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	C. Age approx. 2 3/4 hours.
2	"	$34_{.5}$-$35_{.5}$	50—52	40	— — — —	s s s s	+ + + +	+ + + +	+ + + +	
3	"	35	51—52	60	— — — —	s — + —	+ — + —	+ — + —	+ — + —	
4	"	"	50—52	80	— — — —	— — — —	— — — —	— — — —	— — — —	
5	"	"	50—52	100	— — — —	— — — —	— — — —	— — — —	— — — —	
6	"	"	50—53	120	— — — —	— — — —	— — — —	— — — —	— — — —	
7	"	"	51—54	180	— — — —	— — — —	— — — —	— — — —	— + — —	
8	30°	—	—	0	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	B. Age approx. 7 1/4 hours.
9	"	$34_{.5}$-$35_{.5}$	51—52	60	— — — —	s — — —	s — — —	s — — —	s — — —	
10	"	35	50—52	80	— — — —	— — — —	— — — —	— — — —	— — — —	
11	"	"	50—52	100	— — — —	s — — —	+ — — —	+ — — —	+ — — —	
12	"	"	50—53	120	— — — —	— — — —	— — — —	— — — —	— — — —	
13	"	"	51—54	180	— — — —	— — — —	— — — —	— — — —	— — — —	
14	"	"	51—54	240	— — — —	— — — —	— — — —	— — — —	— — — —	
15	30°	—	—	0	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	A¹. Age approx. 12 3/4 hours.
16	"	35	50—52	60	— — — —	— + + —	— + + —	— + + —	— + + —	
17	"	"	50—52	120	— — — —	— — — —	— — — —	— — — —	— — — —	
18	"	"	50—53	180	— — — —	+ + — +	+ + — +	+ + — +	+ + — +	
19	"	"	50—54	210	— — — —	— — — —	— — — —	— — — —	— — — —	
20	"	"	49—53	240	— — — —	— + — —	— + — +	— + — +	— + — +	
21	"	"	50—54	300	— — — —	— — — —	— — — —	— — — —	— — — —	

From an 18-hour-old culture, inoculate at 8 a.m. into 2.0 broth (tube A). From A, 1 loop is inoculated at 1.5 a.m. into 2.0 broth (tube B). From A, 1 loop is inoculated at 6 a.m. into 2.0 broth (tube C).

Nos. 1-7 from tube C, Nos. 8-14 from tube B.

Immediately before the start of the experiments, 0.02 cm³ of tube A is transferred into 2.0 broth; this appears unchanged and clear afterwards, and from this, Nos. 15-21 are separated

Glass B was noticeably cloudy at the start of the experiments, glass C was still clear. Illumination began at 8:30 and ended at 9:10.

Illumination order (sometimes two at the same time): 2, (3; 9), (4, 10), (5, 11), 6, 12), (7, 13), (14, 20), 11, 17, 18, 19, 21.

age of Nos. 1-7 is therefore 2.5-3 hours, of Nos. 8-14-7-7.5 hours, of Nos. 15-21-12.5-13 hours at illumination

Series 29 (50% Broth). (24/7.99.)

No.	T.	A.	V.	Sec.	1 T.	3 T.	4 T.	5 T.	
1	30°	35	50—52	180	— — — —	s — s —	s — s —	s — s —	Age 13 hours
2	"	"	49—52	210	— — — —	s — s —	s — s —	s — s —	
3	"	"	50—52	247	— — — —	— — — —	— — — —	— — — —	
4	"	"	50—52	270	— — — —	— — — s	— — — s	— — — s	
5	"	"	49—52	300	— — — —	— — — s	— — — s	— — — s	
6	30°	35	50—51	40	— — — —	s s — s	s s — s	s s — s	Age 71 hours.
7	"	"	50—51	80	— — — —	— — — —	— — — —	— — — —	
8	"	"	50—52	100	— — — —	— — — —	— — — —	— — — —	
9	"	"	50—52	120	— — — —	— — s —	— — s —	— — s —	
10	"	"	50—52	150	— — — —	— — — —	— — — —	— — — —	
11	"	"	50—52	180	— — — —	— — — —	— — — —	— — — —	
12	"	—	—	0	? ? ? ?	+ + + +	+ + + +	+ + + +	
13	30°	—	—	0	? ? ? ?	+ + + +	+ + + +	+ + + +	Age 3.5 hours.
14	"	35	50—51	40	— — — —	s s s s	s s s s	s s s s	
15	"	"	50	60	— — — —	s — — s	s — — s	s — — s	
16	"	"	50—51	80	— — — —	s s — s	s s — s	s s — s	
17	"	"	50—52	100	— — — —	— s — —	— s — —	— s — —	
18	"	"	50—52	120	— — — —	— — — —	— — — —	— — — —	
19	"	"	50—52	150	— — — —	— — — —	— — — —	— — — —	

In this series, a broth diluted with equal parts of distilled water was used experimentally to achieve a lighter color. However, it turned out that the bacteria grew considerably more slowly and sparsely in this mixture than usual, which is why this mixture was not used further. Nos. 1-5 were 13 hours old at the start of illumination.

Before the drops were deposited, they were diluted so much that they remained completely clear. Nos. 6-12 are 7.5 hours old, and Nos. 13-19 are 3.5 hours old. Possibly, some of the drops marked * were not sterile, because even the 8 control drops (Nos. 12 and 13) were so slightly cloudy that it was difficult to see with the naked eye.

Row 30. (31/7.99.)

No.	Tp.	A	v.	Sek.	15 St.	36 St.	3T.	4T.	
1	30°	—	—	0	+ + + +	+ + + +	+ + + +	+ + + +	A Age 4 hours.
2	"	35	51—52	20	— — — —	s s s s	s s s s	s s s s	
3	"	"	51	40	— — — —	— s s s	— s s s	— s s s	
4	"	"	50—51	60	— — — —	— — — s	— — s s	— — s s	
5	"	"	50—52	90	— — — —	— — — —	— — — —	— — — —	
6	"	"	50—52	120	— — — —	— — — —	— — — —	— — — —	
7	"	—	—	0	+ + + +	+ + + +	+ + + +	+ + + +	B Age 6 hours.
8	"	35	50—51	20	— — — —	s s s s	s s s s	s s s s	
9	"	"	51	40	— — — —	— — — —	— s — s	— s — s	
10	"	"	50—51	60	— — — —	s — — s	s — — s	s — — s	
11	"	"	50—52	90	— — — —	— — — —	— — — —	— — — —	
12	"	"	50—52	120	— — — —	— s — —	— s — —	— s — —	
13	"	"	51—52	60	— — — —	— — s s	— — s s	— — s s	C Age 814 hours.
14	"	"	51—52	90	— — — —	— — — —	— — s —	— — s —	
15	"	"	51—52	120	— — — —	— — — s	— — s —	— — s —	
16	"	"	50—52	160	— — — —	— — — —	— — — —	— — — —	
17	"	"	50—52	210	— — — —	— — — —	— — — —	— — — —	
18	"	"	50—52	270	— — — —	— — — —	— — — —	— — — —	

From a culture that had been continuously re-bred through four generations before pigment became visible, and which was 8 hours old on July 31st at 8 a.m., all tubes A, B, C, D, E, and F were inoculated. Inoculation took place at 8 a.m. in F, 10 a.m. in E, 12 p.m. in D, 2 p.m. in C, 4 a.m. in B, and 6 p.m. in A.

(Series 30 continued)

No.	Tp.	A	v.	Sek.	15 St.	36 St.	3 T.	4 T.	
19	30°	35	51—52	60	— — — —	— s — —	s s s —	s s s —	D Age 1014 hours.
20	"	"	51—52	90	— — — —	— — — —	— s s —	— s s —	
21	"	"	51—52	120	— — — —	— — — —	s — — —	s — — —	
22	"	"	50—52	160	— — — —	— — — —	— — — —	— — s —	
23	"	"	50—52	210	— — — —	— — — —	— — — —	— — — —	
24	"	"	50—52	270	— — — —	— — — —	— — — —	— — — —	
25	"	"	50—52	120	— — — —	— s s —	s s s —	s s s —	E Age 1234 hours.
26	"	"	50—52	150	— — — —	— — — —	— s s —	— s s —	
27	"	"	50—52	180	— — — —	— — — —	s — — —	s — — —	
28	"	"	50—52	210	— — — —	— — — —	s — — s	s — — s	
29	"	"	49—52	240	— — — —	— — — —	s — — —	s — — —	
30	"	"	50—52	280	— — — —	— — — —	— — — —	— — — —	
31	"	"	50—52	330	— — — —	— — — —	— — — —	— — — —	
32	"	"	50—52	120	— — — —	s s s —	s s s —	s s s —	F Age 14.5 hours.
33	"	"	50—52	150	— — — —	— — — s	— s — s	— s — s	
34	"	"	50—52	180	— — — —	— — — —	s — — —	s — — —	
35	"	"	50—52	210	— — — —	— — — —	— s — —	— s — —	
36	"	"	49—52	240	— — — —	— — s —	— — s —	— — s —	
37	"	"	50—52	280	— — — —	— — — —	— — — —	— — — —	
38	"	"	50—52	330	— — — —	— — — —	— — — —	— — — —	

Lighting started at 9:45 p.m. and finished at 11 a.m.
Lighting order: (2, 8), (3, 9), (4, 10), (5, 11), (6, 12), (13, 19), (14, 20), (15, 21), (16, 22), (17, 23), (18, 24), (25, 32), (26, 33) etc.

Series 31. (4/s. 99.)

No.	Tr.	A.	V.	Sec.	1 T.	2 T.	3 T.	4 T.	
1	44.5°	35	50—51	10	— — — —	s s s s	s s s s	s s s s	45° Age 314 hours.
2	"	"	51	20	— — — —	— s — —	— s — —	— s — —	
3	"	"	51	40	— — — —	— — — —	— — — —	— — — —	
4	"	"	51	60	— — — —	— — — —	— — — —	— — — —	
5	"	"	51	90	— — — —	— — — —	— — — —	— — — —	
6	"	"	51	120	— — — —	— — — —	— — — —	— — — —	
7	"	"	50—51	160	— — — —	— — — —	— — — —	— — — —	
8	30°	"	50	20	— — — —	+ — + s	+ + + +	+ + + +	30° Age 3.5 hours.
9	"	"	51	40	— — — —	— s — s	— + — +	— + — +	
10	"	"	51	60	— — — —	— — — —	— — — —	— — — —	
11	"	"	51	90	— — — —	— — — —	— — — —	— — — —	
12	"	"	51—52	120	— — — —	— — — s	— — — s	— — — s	
13	"	"	51—52	160	— — — —	— — — —	— — — —	— — — —	
14	45°	—	—	0	+ + + +	+ + + +	+ + + +	+ + + +	
15	"	—	—	0	+ + + +	+ + + +	+ + + +	+ + + +	
16	"	—	—	0	+ + + +	+ + + +	+ + + +	+ + + +	

From a 4.5-hour-old culture, inoculate at 6.30 p.m. in 2.0 broth. Thermostat 25° until 8.5 p.m., when the drops began to settle.
Lighting started at 9.40, ended at 10.25. Lighting in numerical order. Nos. 14 and 15 were placed in 45° water for 180 seconds, No. 16 for 300 seconds, without Illumination.
The thermostat was also set to 250 for the following rows.

Series 32. (8/8. 99.)

No.	Tr.	A.	V.	Sec.	1 T.	2 T.	3 T.	8 T.	
1	15°	—	—	0	+ + + +	+ + + +	+ + + +	+ + + +	
2	45°	—	—	0	+ + + +	+ + + +	+ + + +	+ + + +	
3	45°	35	50	10	— — — —	s — — s	s — — s	+ — — +	45° Age: 4 hours. Age: 3.5 hours, Age: 3 hours.
4	"	"	51	20	— — — —	— s — —	— s — —	— + — —	
5	"	"	51	40	— — — —	— — — —	— — — —	— — — —	
6	"	"	50	60	— — — —	— — — —	— — — —	— — — —	
7	"	"	50—51	90	— — — —	— — — —	— — — —	— — — —	
8	30°	35	51	20	— — — —	+ + + +	+ + + +	+ + + +	30°
9	"	"	51	40	— — — —	— + + —	— + + —	— + + —	
10	"	"	51	60	— — — —	— — — —	— — — —	— — — —	
11	"	"	50—52	90	— — — —	— — — —	— — — —	— — — —	
12	"	"	approx. 51	120	— — — —	— — — —	— — — —	— — — —	
13	15°	35	51	20	— — — —	s + + +	+ + + +	+ + + +	15°
14	"	"	51	40	— — — —	— + — —	— + — —	— + — —	
15	"	"	50—51	60	— — — —	— + — —	— + — —	— + — —	
16	"	"	51—52	90	— — — —	— — — —	— — — —	— — — —	
17	"	"	50—51	120	— — — —	— — — —	— — — —	— — — —	

From 6.5 h of old culture (from a 12 h old culture that grew at 250) at 6:30 p.m., inoculate into 2.0 bouillon, which is kept at 250. All drops of this are dispensed between 8:45 and 9:30. Illumination began at 9:30 and ended at 10:45, in numerical order. No. 2 was placed in 450 water for 120 seconds without illumination.

Row 33 (12/8.99).

From a culture approximately 3 hours old, 28 drops were illuminated at 450 for 10-60 seconds, 24 drops at 300 for 20-120 seconds, and 24 drops at 150 for 20-120 seconds. 12 drops served as a control without illumination. All preparations remained sterile with the exception of one of the four drops that had received 10 seconds of light at 450, one of the four that had received 20 seconds of light at 150, and the 12 control drops. However, these latter all grew very sparsely, were only "s" in the first three days, and only on the fourth day did the scattered growth centers confluent into a weak, diffuse turbidity. Why this culture was weakened from the start, I do not know

Series 34. (16/8. 99.)

No.	Tr.	A.	V.	Sec.	1 T.	2 T.	3 T.	4 T.	5 T.	7 T.	Sec.	
1	45°	35	51	5	— — — —	s s s s	s s s s	s s s s	s s s s	s s s s	5	45° Age 5 hours.
2	"	"	51	10	Koko	s s s s	s s s s	s s s s	s s s s	s s s s	10	
3	"	"	51	15	— — — —	s s s —	s s s —	s s s —	s s s —	s s s —	15	
4	"	"	51.5	20	— — — —	— s s s	— s s s	s s s s	s s s s	s s s s	20	
5	"	"	51	30	— — — —	— — — —	— s — s	— s — s	— s — s	— s — s	30	
6	"	"	51—52	40	— — — —	— — — —	— s — —	— s — s	— s — s	— s — s	40	
7	"	"	50—51	60	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	60	
8	"	"	48—52	100	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	100	
9	30°	35	51	10	s s s —	s s s s	s s s s	s s s s	s s s s	s s s s	10	30° Age 5.5 hours.
10	"	"	51—52	20	— — — —	s s s s	s s s s	s s s s	s s s s	s s s s	20	
11	"	"	51	30	— — — —	s s s s	s s s s	s s s s	s s s s	s s s s	30	
12	"	"	51	40	— — — —	— s s s	— s s s	— s s s	— s s s	— s s s	40	
13	"	"	51—52	60	— — — —	s — — s	s — — s	s — — s	s — — s	s — — s	60	
14	"	"	51—52	100	Koko	— — — —	— — — —	— — — —	— — — —	— — — —	100	
15	"	"	51—52	150	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	150	
16	15°	35	51	10	s s s s	s s s s	s s s s	s s s s	s s s s	s s s s	10	15° Age 614 hours.
17	"	"	51	20	— — — —	s s s s	s s s s	s s s s	s s s s	s s s s	20	
18	"	-	51	30	— — — —	s s s s	s s s s	s s s s	s s s s	s s s s	30	
19	"	"	51—52	40	— — — —	s s s s	s s s s	s s s s	s s s s	s s s s	40	
20	"	"	50—51	60	— — — —	s — — s	s — — s	s — — s	s — — s	s — — s	60	
21	"	"	50—52	100	— — — —	— — — s	— — — s	— — — s	— — — s	— — — s	100	
22	"	"	51—52	150	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	150	
23	—	—	—	0	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	0	
24	45°	—	—	0	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	0	

From a 13.5-hour-old culture, inoculate 1.5 p.m. in 2.0 broth (tube A) and 4.45 p.m. in 2.0 broth (tube B).

Nos. 1-24 are removed from tube B immediately before the start of the experiments, and Nos. 25-49 1.5 hours earlier from tube A. Illumination began at 9.40 a.m. and ended at 11 a.m.

Illumination in numerical order, but always two at a time (1 and 25, 2 and 26, etc.).

(continued pp. 72-73)

To regulate the current, a new resistor was used, consisting of 21 incandescent lamps, which were connected individually or in groups in parallel with the ordinary Rheostats are to be switched; this allows the current to be maintained so precisely at 35 amperes that the error hardly exceeds 1/10 ampere. Only during the illumination of Nos. 8 and 32 was the current 36 amperes for a few seconds, while the lamp regulated itself

(Series 34 continued.)

No.	Tp.	A.	V.	Sec.	1 T.	2 T.	3 T.	4 T.	5 T.	7 T.	Sec.	
25	45°	35	51	5	s s s —	s s s s	s s s s	s s s s	s s s s	s s s s	5	45° Age: 8.5 hours.
26	"	"	51	10	s s s —	s s s s	s s s s	s s s s	s s s s	s s s s	10	
27	"	"	51	15	— s — —	s s s s	s s s s	s s s s	s s s s	s s s s	15	
28	"	"	51-5	20	— — — —	s s s s	s s s s	s s s s	s s s s	s s s s	20	
29	"	"	51	30	— — — —	s — s s	s — s s	s — s s	s — s s	s — s s	30	
30	"	"	51—52	40	— — — —	— — s —	— — s —	— — s —	— — s —	— — s —	40	
31	"	"	50—51	60	— — — —	— — — —	— s — s	— s — s	— s — s	— s — s	60	
32	"	"	48—52	100	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	100	
33	30°	35	51	10	s s — —	s s s s	s s s s	s s s s	s s s s	s s s s	10	30° Age: 8.5 hours.
34	"	"	51—52	20	s — — —	s s s s	s s s s	s s s s	s s s s	s s s s	20	
35	"	"	51	30	— — — —	s s s s	s s s s	s s s s	s s s s	s s s s	30	
36	"	"	51	40	— — — —	s s s s	s s s s	s s s s	s s s s	s s s s	40	
37	"	"	50—52	60	— — — —	— s — s	— s s s	— s s s	— s s s	— s s s	60	
38	"	"	50—52	100	— — — —	— — s —	— — s —	— — s —	— — s —	— — s —	100	
39	"	"	51—52	150	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	150	
40	15°	35	51	10	— — s —	s s s s	s s s s	s s s s	s s s s	s s s s	10	15° Age: 9.5 hours.
41	"	"	51	20	— — s s	s s s s	s s s s	s s s s	s s s s	s s s s	20	
42	"	"	51	30	— — — —	s s s s	s s s s	s s s s	s s s s	s s s s	30	
43	"	"	51—52	40	— — — —	s s s s	s s s s	s s s s	s s s s	s s s s	40	
44	"	"	50—51	60	— — — —	s s s s	s s s s	s s s s	s s s s	s s s s	60	
45	"	"	50—52	100	— — — —	— — s s	s s	s s	s s	s s	100	
46	"	"	51—52	150	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	150	
47	—	—	—	0	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	0	
48	45°	—	—	0	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	0	
49	"	—	—	0	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	0	

Nos. 24, 48, and 49 were placed in 450 ml of water without light, 24 and 48 for 2 minutes, and 49 for 3 minutes. Nos. 23 and 47 received neither heat nor light. The ages of 1: 244, 55, and 6:15 hours; of 25: 498, 10, and 9:30 hours.

All drops were inoculated into bouillon jars on the 7th day; all were found to be pure cultures of Prodigiosus, and all remained sterile

Series 35. (20/8. 99.)

No.	Tr.	A.	V.	Sec.	16 hrs.	3 T.
1	30°	—	—	0	++ ++	++ ++
2	"	35	51—54	60	++ ++	++ ++
3	"	"	51—53	120	++ ++	++ ++
4	"	"	52—53	180	++ ++	++ ++
5	"	"	50—53	240	++ ++	++ ++
6	"	"	51—54	300	++ ++	++ ++
7	30°	—	—	0	++ ++	++ ++
8	"	35	50—53	60	++ ++	++ ++
9	"	"	51—52	120	++ ++	++ ++
10	"	"	50—53	180	++ ++	++ ++
11	"	"	51—54	240	++ ++	++ ++
12	"	"	50—53	300	++ ++	++ ++

As a control experiment to see whether the quality of the broth changed by the illumination played a role in the previous series of experiments, four sterile broth drops were placed on each of the cover quartz crystals 1-12, after which the illumination was carried out as usual. Immediately after illumination, all drops were inoculated: Nos. 1-5 from a 24-hour-old Prodigiosus culture, Nos. 7-12 from a 4-hour-old one. After 16 hours, all drops of Prodigiosus were level and strongly turbid. Inoculation was carried out with the tip of a 0.2 mm thick platinum wire without an eyelet so that large quantities of the unilluminated broth were not transferred simultaneously with the inoculation.

It can be seen from this experiment that the light intensity used in the present experiments did not noticeably change the properties of the broth as a nutrient medium at the times in question.

Series 36. (25/5. 99.) (continued on pp. 76-77.)

No	Tr.	A.	V.	Sec.	1 T.	2 T.	3 T.	4 T.	15 T.	Sec.	
1	15°	35	50	30	— —	s —	— +	— +	— +	30	15° After 4 Stunden.
2	"	"	50—51	50	— —	s —	— +	— +	— +	50	
3	"	"	50—51	70	— —	— s	— —	— —	— —	70	
4	"	"	50—52	100	— —	— —	— —	— —	— —	100	
5	"	"	50—52	130	— —	— —	— —	— —	— —	130	
6	30°	35	50	30	— —	s s	++	++	++	30	30° After 4.20 Stunden.
7	"	"	50—52	50	— —	— —	— —	— —	— —	50	
8	"	"	50—51	70	— —	— —	— —	— —	— —	70	
9	"	"	50—52	100	— —	— —	— —	— —	— —	100	
10	"	"	50—52	130	— —	— —	— —	— —	— —	130	
11	45°	35	50	20	— —	— —	— —	— —	— —	20	45° After 4.40 Stunden.
12	"	"	50—52	40	— —	— —	— —	— —	— —	40	
13	"	"	50—51	60	— —	— —	— —	— —	— —	60	
14	"	"	50—52	80	— —	— —	— —	— —	— —	80	
15	"	"	50—52	100	— —	— —	— —	— —	— —	100	
16	"	"	50—52	130	— —	— —	— —	— —	— —	160	

Series 35. (20/8. 99.)

No.	Tr.	A.	V.	Sec.	16 hrs.	3 T.
1	30°	—	—	0	++ ++	++ ++
2	"	35	51—54	60	++ ++	++ ++
3	"	"	51—53	120	++ ++	++ ++
4	"	"	52—53	180	++ ++	++ ++
5	"	"	50—53	240	++ ++	++ ++
6	"	"	51—54	300	++ ++	++ ++
7	30°	—	—	0	++ ++	++ ++
8	"	35	50—53	60	++ ++	++ ++
9	"	"	51—52	120	++ ++	++ ++
10	"	"	50—53	180	++ ++	++ ++
11	"	"	51—54	240	++ ++	++ ++
12	"	"	50—53	300	++ ++	++ ++

As a control experiment to see whether the quality of the broth changed by the illumination played a role in the previous series of experiments, four sterile broth drops were placed on each of the cover quartz crystals 1-12, after which the illumination was carried out as usual. Immediately after illumination, all drops were inoculated: Nos. 1-5 from a 24-hour-old Prodigiosus culture, Nos. 7-12 from a 4-hour-old one. After 16 hours, all drops of Prodigiosus were level and strongly turbid. Inoculation was carried out with the tip of a 0.2 mm thick platinum wire without an eyelet so that large quantities of the unilluminated broth were not transferred simultaneously with the inoculation.

It can be seen from this experiment that the light intensity used in the present experiments did not noticeably change the properties of the broth as a nutrient medium at the times in question.

Series 36. (25/5. 99.) (continued on pp. 76-77.)

No	Tr.	A.	V.	Sec.	1 T.	2 T.	3 T.	4 T.	15 T.	Sec.	
1	15°	35	50	30	— —	s —	— +	— +	— +	30	15° After 4 Stunden.
2	"	"	50—51	50	— —	s —	— +	— +	— +	50	
3	"	"	50—51	70	— —	— s	— —	— —	— —	70	
4	"	"	50—52	100	— —	— —	— —	— —	— —	100	
5	"	"	50—52	130	— —	— —	— —	— —	— —	130	
6	30°	35	50	30	— —	s s	++	++	++	30	30° After 4.20 Stunden.
7	"	"	50—52	50	— —	s s	— —	— —	— —	50	
8	"	"	50—51	70	— —	— —	— —	— —	— —	70	
9	"	"	50—52	100	— —	— —	— —	— —	— —	100	
10	"	"	50—52	130	— —	— —	— —	— —	— —	130	
11	45°	35	50	20	— —	— —	— —	— —	— —	20	45° After 4.40 Stunden.
12	"	"	50—52	40	— —	s —	s —	s —	s —	40	
13	"	"	50—51	60	— —	— —	— —	— —	— —	60	
14	"	"	50—52	80	— —	— —	— —	— —	— —	80	
15	"	"	50—52	100	— —	— —	— —	— —	— —	100	
16	"	"	50—52	130	— —	— —	— —	— —	— —	160	

The explanation of the experiments.

The first 12 series of experiments are only exploratory, sometimes rather tentative, experiments, as will become clear from the notes appended to each series. In particular, an exact indication of the age of the cultures is missing, and since it has turned out that this moment is of crucial importance, I will omit these first 12 series entirely in the following. The following series are also not all of equal value. In particular, a special position is occupied by the following series

:

Series 14 and 33: The cultures were already attenuated before illumination (see the notes in the experimental protocol).

R. 15 and R. 19: The illumination time was chosen so unfortunate that the killing time was not determined.

R. 25: The culture was contaminated with another microorganism

R. 29: The broth used is 50% thinner than usual, so that the "age" of the bacteria cannot be easily compared with the age of the bacteria in the other series of experiments.

Furthermore, the later series are, of course, on the whole, more reliable than the earlier ones, because I gradually gained more practice and introduced more and more precautionary measures. In particular, the experiments from series 21 onwards must have gained in value because, from this time onwards, I always deposited several, usually four, drops on each covering quartz. For in cases where all four drops gave the same result, the experiment must be considered more reliable than if only one drop had been deposited. And upon closer examination of those cases where part of the four drops was sterilized while the rest showed growth, I became aware of conditions that led me to believe that in one and the same culture

that not all individuals are equally resistant, and in particular that a small number of bacteria can be more resistant to light than the majority of them.

It has been found to be quite constant that, as the illumination time approaches the "absolute killing time" (i.e., the illumination time that definitely kills all individuals in the culture), growth occurs on the same covering quartz only in some of the drops, but not in others. When looking through R. 22-36, it will be difficult to escape the impression that some bacterial individuals in every bacterial culture must be more resistant than the others because they can withstand an illumination time to which their otherwise equal comrades are subject. We further see that the most resistant are in the minority compared to the weaker ones; For in each sterilized drop there were originally hundreds or thousands of bacteria, not a single one of which proved to be resistant, whereas every drop in which growth occurred proves nothing other than that at least one resistant microorganism was present. Higher degrees of resistance are generally found in a number that decreases with increasing resistance; for the closer we approach the absolute killing time, the more consistently it becomes that of the four drops, at most one, shows growth, and where the times have been chosen to be of a suitable length, we see a fairly even increase in the number of sterilized drops on each covering quartz (see, for example, R. 30 to R. 36). We often see that there was not a single living bacillus in the four drops, as all four proved to be sterilized, despite the fact that the absolute killing limit had apparently not yet been reached, as we can see on the next or perhaps

only on the second-nearest covering quartz do we see growth again in a single drop. For example, in R. 23, Nos. 12-22, we saw how, with 20 seconds of illumination, all 4 drops showed growth; at 30 seconds, 3 of 4; at 40 and 50 seconds, 1 of 4; at 60 seconds, 0 of 4; at 70-90 seconds, again 1 of 4; at 100 seconds and above, 0 of a total of 12 drops. If a sufficient number of drops had been deposited in No. 15 (60 seconds), growth would probably have been seen in a certain number of them. The same can be said, but with far less probability, of Nos. 20-22 (100 seconds and more). Therefore, it is necessary to have an overview of the entire series before one can judge to what extent the sterility of all four drops indicates that the safe kill limit has been reached. Of course, the probability that the latter is the case is much greater if the previous numbers have already shown an increasing number of sterile drops. For this reason, in numbers 13-20, where only one drop has been deposited on each cover quartz, the kill limit cannot be determined with as much accuracy as in the later series. If, for example, No. 15 in number 16 is sterilized, this is obviously analogous to, for example, No. 3 in number 22 having three sterile drops out of four. The kill limit in R. 16 is evidently somewhere between 60 and 120 seconds; even 120 seconds would not be reliable if we had not just seen that numerous individuals had already perished at 20 and 30 seconds (i.e., Nos. 15 and 17). More difficult to interpret are the cases, which are incidentally only few, where, as in R. 22, Nos. 13-24, after a larger number of sterile numbers, growth suddenly appears in a single drop of 4. Whether in this case this means that the kill limit is above 120 seconds, or the number of resistant individuals in this culture was unusually small, or whether Nos. 18 and 22 are to be understood as

"coincidences" that have remained in life, e.g The possible causes, e.g., that some bacteria were shaded by a speck of dust, or due to other experimental errors, cannot be determined from the series itself. However, the interpretation of these becomes less difficult when we see the results of these series alongside those of the other series in a graphic representation (see below). If, for example, For example, if No. 12 in R. 31 shows growth in a single one of four drops, while the two preceding numbers (10 and 11) with a total of eight drops were completely sterilized, and the cultures with an even shorter illumination time (No. 9) already had some sterilized drops, it becomes likely that No. 12 is due to "chance", especially when we also see that in all other series with cultures of corresponding age the kill limit is approximately half the illumination time of that for which No. 12 was exposed (see the graphic representation, Table 1, where No. 12 is marked as a small circle).

My view that only a few individuals in any culture are more resistant than the majority of bacteria is also confirmed by the study of the "scattered" (denoted by s) colonies. Without wishing to go into this interesting phenomenon in more detail for now, I will only report how this form of growth manifests itself in direct observation. While all unlit control drops are diffusely cloudy from the growing culture after approximately eight to ten hours, the scattered growth always appears later (at the earliest, the 15th to 20th hour) and originates from one or more discrete points in the drop. Such a point appears, where I have observed one at the earliest so far, as a cluster of bacteria just visible to the naked eye, stuck directly on the underside of the covering quartz. Microscopically, this cluster consists of

from densely packed masses of bacteria, while no growth is observed anywhere else in the liquid, only a few evenly distributed bacteria, which are evidently the bacteria originally present in the drop but killed by the light; for their number remains unchanged over the following days, while the s-spot grows very quickly into a compact hemisphere up to 1 mm in diameter, with rapid, vivid red pigment formation, which is usually already evident from the 24th hour onwards (while the diffusely growing cultures only acquire a diffuse reddish color quite late, on about the third or fourth day). Only in rarer cases (see experimental protocol) does diffuse growth later occur in the drop around this bacterial colony. In most cases, such an s-colony persists unchanged for days or weeks, and neither macroscopically nor microscopically can one find any signs of growth anywhere in the surrounding broth Generally speaking, one can say that the shorter the illumination time, the more numerous the s of each individual drop. Where all four drops yield s (e.g., R. 36 No. 24), there are usually several, up to ten; where only some of the four drops show growth, only one s is found, rarely a pair in each drop (e.g., R. 36 No. 26); in isolated surviving cultures (such as No. 23 or No. 28 of the same series), there is always only one. This scattered growth, originating from isolated points, the number of which decreases with increasing illumination time, is thus consistent with the circumstance discussed (p. 79) that the number of sterilized drops on each cover quartz increases with illumination time, and can, like this, find the simplest (but of course not the only possible) explanation in the fact that only a few individuals were more resistant than the majority. The possible cause of this individual resistance,

I will discuss in more detail below. The reasons why they grow as a clump and do not grow into the rest of the drop are as yet unknown to me.

I discussed earlier (p. 10) that an actual attenuation has not yet been proven by the commonly used Buchner method, but that what has been interpreted as an attenuation can be explained by the fact that some of the bacteria in the culture in question are killed and only some of them remain alive, without being forced, based on previous experimental results, to assume a reduced vitality of the surviving individuals. On the other hand, I believe that in my series of experiments, an unmistakable attenuation can be observed. When the cultures are examined for the first time after illumination, usually 12-15 hours later, we see that the illuminated drops are almost always still quite clear, whereas the control drops are all already very turbid One will see from the experimental protocol that a culture can only exceptionally tolerate 30 seconds of illumination without its development being retarded; indeed, usually 10 seconds, sometimes even 5 seconds, are sufficient to bring about this result. On the whole, we see an increasing retardation of development with increasing duration of illumination; where such a retardation is not evident in the tables, it is simply because the first burst of growth was not always noted immediately, the results being recorded only at certain times of day (usually morning and evening) for practical reasons. R. 24 shows that if the culture is observed at sufficiently short intervals, a certain proportionality between the illumination time and the retardation of growth becomes clearly apparent. Incidentally, this relationship can also be seen clearly enough, e.g. B. in R. 14 (10-16), 18, 19 (1-23), 20, 21, 23, 25, 27 (7-12), 28, 30, 34, 36 (29-34).

Now, one could perhaps object that this delayed growth of the colonies could be caused by the fact that the majority of the bacteria had been killed, so that only so few bacteria remained alive that they needed longer than usual to populate the drop to such an extent that the growth became visible to the naked eye, or that, in other words, here too there was a reduction in number, i.e., a dilution, but not a weakening. The following should be emphasized:

1. Only a single surviving bacillus, if its vitality was to be unimpaired, had to be able to populate the drop faster than after 50-60 hours (R. 21.6, 24-11, 28.20, 30.27, 14, 35, 36-32) or even on the 4th day (R. 18.9, 23.6, 30.22, 34-6).

2. We have seen how isolated surviving bacteria (namely s,

The "scattered" ones can very well give clearly visible growth quite early (e.g., R. 22 within 19 hours, R. 23, R. 24, and R. 25 within 17 hours, R. 27 within 14 hours), but where they have been illuminated close to the kill limit, they nevertheless often only appear very late (e.g., R. 36, 32, 34-6, 30, 22, and many others).

3. In R. 24, we see how an illumination time of just 1-3 seconds can delay development. It would be artificial to assume that an illumination time of just 1 second would have killed the majority of the drop's inhabitants in a culture where the absolute kill limit is higher than 50 to 60 seconds

4. We often see that both the diffusely growing drops (+) and the scattered ones (s) are delayed. As far as I can see, it would require a very complicated hypothesis to reconcile these four facts without assuming an attenuation of the bacteria.

Incidentally, I am far from proposing the theory of a few resistant individuals in each culture, or the theory of the attenuation of individual bacteria by light, as proven by my experiments. I only propose them as the simplest explanation I have been able to find. Nor do I base the following conclusions on these theories.

Therefore, when I use the word "attenuation" in the following, one need understand nothing other than the fact that the culture in question grew later than the control cultures, and by "dilution" I mean only the fact that only a portion of the drops on the same covering quartz showed growth

I need not go into detail here about what is known about the two conditions discussed, examined by attenuating agents other than light. I will only remind you that it has also been believed that it is possible to detect "exceptional cells" in other ways,

individual individuals that behave differently in certain respects than the majority of bacteria in the culture in question.

The Influence of the Age of the Culture.

Although some earlier investigators have stated the approximate age of the cultures used, I have not been able to find a systematic study in the literature on the influence of age on the resistance of bacteria to light

That the resistance of the Prodigiosus to light increases with the age of the culture is proven by all experiments directed at this point, namely series 13, 14, 18, 20, 21, 27, 28, 29, 30, 34, 36, and nowhere does a conclusive experiment contradict this. Everywhere we see that the absolute killing time (p. 79) is shorter for the younger cultures than for the older ones

Within each of the series mentioned here, the temperature was kept constant; the young and old cultures were illuminated either simultaneously or immediately after each other, often alternately. In general, the old and young cultures within each experimental series were treated exactly the same from beginning to end. The proof is therefore, as far as I can see, conclusive. Incidentally, it is not only the absolute killing time that increases with age; we also see that the "dilution" (p. 84) occurs in accordance with this. It is, so to speak, constant that the dilution in the younger cultures becomes apparent after shorter illumination times than in the older ones, and where the illumination times are fortunately chosen, we see that with illumination that produces a strong dilution in a younger culture, a weaker dilution occurs

thinning conditions in the older cultures (e.g., R. 34, Nos. 5 & 29, Nos. 13 & 37, Nos. 21 & 45, R. 36, Nos. 2 & 19, Nos. 11 & 29).

If one now wants to compare the various series with each other and also include experiments carried out in other respects (e.g., to investigate the influence of heat), one cannot, of course, expect mathematically exact agreement between experiments spread over a period of half a year, during which the experimental technique gradually developed. It must be all the more convincing if, nevertheless, these experiments, placed side by side, produce a reasonably uniform result, so that the smallness of the variations is rather surprising when one considers how capricious the growth conditions of bacteria often are

In order to be able to record the results graphically in an easily understandable form, one must take into account that the killing time for the method used is not specified by a single, specific number, but rather by finding a larger or smaller range within which it must lie. If, for example, in R. 34, No. 13 has fully grown despite 60 seconds of illumination, while Nos. 14 and the following were sterilized with at least 100 seconds of illumination, the killing limit probably lies somewhere between 60 and 100. On the graphic representation, I will indicate such an experiment by a vertical line drawn solid up to 60 and from there dashed to 100. The dashed section then indicates the range, and the killing limit can be imagined anywhere within it; In many cases, if one surveys the series in question as a whole, taking into account the "dilution" and the "attenuation," one can judge quite well at which point

the margin, the probable killing limit, lies. But in order not to introduce a point that appears more or less arbitrary, I have not provided such a curve for the probable killing time. Anyone interested will be able to construct one using the experimental protocol.

On Plate I, I have shown the most complete and uniform

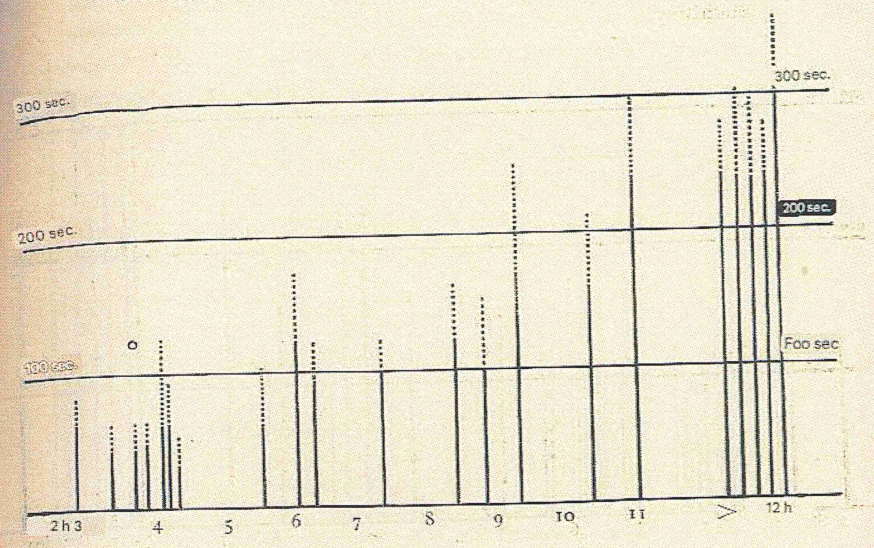


Plate I

The sixth of the series of experiments is shown, namely all those conducted at 300°C and with more than one drop on each cover quartz. I have only excluded R. 29, where a different type of broth is used than for the other experiments (incidentally, the relative values, namely the increase in resistance with age, are the same as in the other series, but the absolute values for each individual age group are slightly different).

One can see how the killing time, which for 3- to 4-hour-old cultures is between approximately 40 and 80 seconds, reaches values between 100 and 120 seconds at the 6th to 7th hour, approaching 200 seconds during the 8th to 11th hour. From the 12th to the 12th hour, this limit is exceeded, and the bacteria are only reliably killed between 250 and 300 seconds; some even survive 300 seconds of illumination.

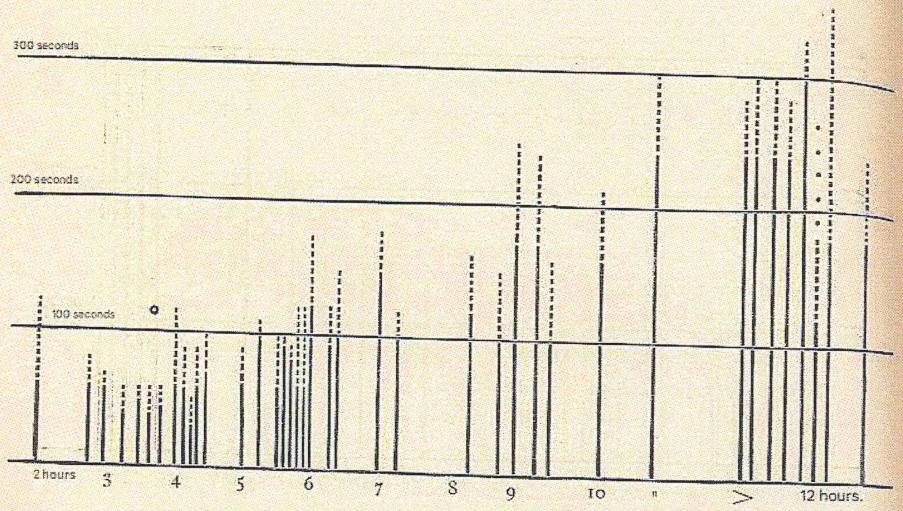


Plate II

In essence, the same picture emerges when I include all the other series where the age is given at all (Plate II), i.e., both the series where the mortality limit is less precisely determined because there was only one drop on each covering quartz, as well as the experiments where temperatures other than 300°C were used (namely, 150, 180, 200, 260, 36°C). However, I did not include the experiments conducted at 450°C; because, although

Although this shows the influence of age in the same way, the absolute values here, precisely because of the temperature (see p. 93), are so deviant that they would only make the interpretation of the image more difficult. I have also excluded R. 14 (see the note on this in the experimental protocol), R. 15, 17, 19, where the killing limit was not reached at all, R. 22 (13-24), where the limit was uncertain, R. 25, where the culture was contaminated, and R. 29, where a different type of broth was used. I have not included R. 16 because it is doubtful what age should be assigned to it (cf. note on R. 16).

We see that the image (Plate II), despite the fact that some not entirely pure cases have been included, has retained the same character: increasing resistance to light with increasing age

Some experiments have indicated that we have already reached a maximum of resistance at an age of approximately 12 hours, with cultures of 2-3 days (R. 13 and 14) and 1-2 months (R. 20) appearing no more resistant than the 1- to 14-hour-old cultures. The 4- to 5-day-old culture in R. 21 survived 300 seconds of illumination. However, we must, of course, await further experiments in this area

The resistance of very young, 1/2-1 hour-old cultures must be investigated as a special question. It has been shown, for example, in Series 21, that if a certain amount of an old broth culture is transferred to sterile broth and then illuminated, which requires at least 1/2 hour for the preparation of the specimens, etc., this mixture still behaves as an "old" culture with regard to killing time. One might therefore perhaps obtain some clarity about how quickly the old bacteria rejuvenate themselves by division if one examined the period between 1/2 hour and 3 hours to see when and how quickly the culture converts its high killing time into a low one. This must be reserved for future investigations.

If one considers the great importance of age for resistance with the two relationships discussed earlier, namely that the number of most resistant individuals is probably relatively small, and that

Increasing degrees of resistance are found on the whole in an ever-decreasing number of individuals the closer one approaches the kill limit, one could perhaps assume that it is the oldest individuals that are the most resistant. If one were to imagine that in a culture there existed at all times a number of individuals who, for some reason or other, did not divide, but assumed a, if you will, "sporoid" state, which became more and more pronounced with age, such individuals would have to appear in a similar way to what I have found characteristic of the most resistant individuals. In one, for example, For example, in a culture 12 hours old, as we have seen, one probably finds not only individuals with maximum resistance (i.e., 250-300 seconds of killing time), but also others, and indeed more numerous, whose killing time is around 200 seconds, others even more numerous around 100 seconds, while the vast majority, just like the younger cultures, are killed in less than 100 seconds. Why very young individuals, say, for example, 1/2 hour old, should be distributed according to such a scale because they were born in an old culture could only be explained by an artificial hypothesis, since they are born under exactly the same conditions. But we would have a relatively simple explanation if we assume the existence of the discussed "sporoid" individuals of different ages with correspondingly different levels of resistance. Such individuals would probably have to be distributed, in terms of number, according to a scale like the one mentioned, since the production of "sporoid" individuals would probably have to be in a certain relationship to the absolute number of individuals of which the culture consisted at a certain point in time.

This is only a suggestion for a hypothesis; should it

find confirmation, it might be worth the effort to investigate whether other types of "exceptional cells" can be interpreted in a similar way.

What this greater resistance of the older cultures is actually based on, I leave to debate until further investigations are available, since the current investigations are only complete insofar as they have discussed some of the most important conditions for obtaining consistent experimental results—which therefore primarily requires consideration of the age of the culture, at least when working with Prodigiosus But whether other bacteria behave in a similar manner, whether chemical changes in the nutrient medium play any role, whether pigment formation is a contributing or perhaps even the sole cause, whether there are truly vital changes in the bacterial bodies or more accessory conditions in the culture, such as the larger number of individuals per unit volume or perhaps simply clumping due to a type of agglutination in older cultures, or finally, a reduced permeability to bacteriocidal rays with age, either of the bacterial bodies or of the nutrient medium, are matters that must be reserved for future investigations. However, my experiments reported here already provide a clue to the solution of some of these questions; I will mention the following, for example:

Mei1. It is unlikely that a change in the chemical composition of the nutrient medium with the age of the culture is decisive for the resistance acquired with age. For in R. 21, R. 27, and R. 28 (cf. also R. 20, R. 29), only 0.04 cm^3, 0.06 cm^3, and 0.02 cm^3 of the old culture were transferred into 2.0 cm^3 of sterile virgin broth; despite this strong dilution, the cultures illuminated as quickly as possible thereafter behaved like old cultures

2. These same experiments also contradict the idea that a reduced radiance of the nutrient medium with age is decisive.

3. The importance of pigment formation can be demonstrated most clearly through experiments with non-pigmented bacteria. That pigment formation is important for very old cultures with a macroscopically clear pigment layer is beyond question. But we see numerous examples in the series of experiments that resistance is significantly increased at a time when neither macro- nor microscopic pigment can be detected in the cultures; but I cannot, of course, definitively deny from these experiments that some individuals were protected by pigment

4. That the cause could lie in the increasing number of bacteria per unit volume with age, whereby some bacteria overshadow others, is an obvious thought, and if the culture is highly turbid, this will probably actually occur; but based on the following experiments, I do not believe that it was of any importance in my experiments:

In R. 20, we saw that the 1-2 month-old culture, which was so highly diluted with sterile broth that it was clear, was more difficult to kill than the 6-hour-old culture, even though the latter was already turbid.

From R. 21, it can be seen that it does not make much difference whether one has 1 or 25 bacteria per unit volume.

In R. 27, 28, 29, the old cultures were so highly diluted that they were clear, while the younger cultures were turbid; nevertheless, the latter were killed more quickly than the former

5. It would be an obvious idea to attribute some significance to the formation of clumps of bacteria clustered together, which increases with the age of the culture.

for the greater resistance of the old cultures. In cultures more than one day old (R. 13, 14, 20, 21), such clumps are constantly found; in these cases, it is therefore not likely that the clumps may have played a role. But in the experiments where the culture was 3-14 hours old, no clumps were found in the drops sitting on the cover quartz when they were examined microscopically, either immediately after they had been deposited on the cover quartz or the day after illumination. Moreover, the regularity with which both the thinning and the complete sterilization occur speaks against the idea that clump formation was decisive

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Whatever the reason for the resistance of older cultures, it seems to me to be of biological interest that a Prodigiosus culture, over the course of about 10 hours—for example, over the course of one night—achieves such resistance to light that it can endure 5-6 times more light than when it was 3 hours old.

The influence of temperature.

Since several researchers (e.g., d'ARCY and HARDY, DOWNES and BLUNT, DUCLAUX, GAILLARD, KRUSE, LAURENT, MOMONT, RASPE, ROUX, MARSHALL WARD, WESBROOK) have stated that the effect of light on bacteria is based on oxidation, it is obvious to investigate whether the effect of light, like most other oxidation processes, increases with rising temperature. As far as I know, there is no

exhaustive investigations into this. Saverio Santori is said to have found that sunlight is less powerful at lower temperatures than at higher ones. I do not know his work in the original, but since other of his results, as a result of presentations, are in complete contradiction with what we otherwise consider to be established, one cannot attach much importance to his work. Kruse conducted a single series of experiments with typhus broth cultures in test tubes, which he exposed to sunlight in shallow dishes containing water at approximately 0°C, approximately 16°C, and approximately 35°C. He believes he can conclude from this experiment that the effect of sunlight increases with temperature. But, apart from the errors generally inherent in test-tube experiments (p. 7) and the small number of experiments, the results themselves do not seem very convincing to me He found, by counting the colonies, that at 0°C, 2 hours of illumination were necessary to achieve the same degree of "attenuation" that was achieved at 16°C by 1 hour of illumination and at 35°C by 2 hours of illumination. According to this, one would believe that the effect at 35°C was weaker than at 16°C. Kruse, however, thinks the opposite. He considers the light effect at 35°C to be stronger than that at 16°C because the culture initially grew more strongly at 35°C than at the other temperatures and was therefore later "attenuated." This latter reasoning is correct enough in itself, but the first conclusion is not compelling. One can admit that these experiments do not contradict a stronger light effect at higher temperatures, but the experiments (at least for the temperature 35°C) do not contain any evidence for such an assumption.

My own experiments on the influence of temperature (besides the fact that I always maintained a constant temperature in the

individual series of experiments) are carried out in such a way that drops taken from one and the same culture were exposed to light at different temperatures of the water surrounding the preparations. I carried out the following such experiments:

Series 15 and Series 17, where no result was obtained because the killing limit was not reached.

Series 16 shows no noticeable difference between 200 and 300, but the series of experiments were so unfortunate that a large lacuna was present at the crucial point (between 60 and 120 seconds).

R. 22 is not conclusive with regard to the killing time, because the assessment depends entirely on whether one wishes to regard No. 22 as a "chance" or not. But the "dilution" is much greater at 35° than at 150°

R. 23 gives the killing time for 180 between 100 and 110 seconds, while for 360 it is between 90 and 100 seconds. The difference is only small, but it is increased by the fact that both the attenuation and the "dilution" are more pronounced at 360 than at 180. And although the culture, when illuminated at 36°C, had become half an hour older than the drops illuminated at 18°C and consequently, as we saw, must have become more resistant, it was nevertheless killed more quickly. Finally, the result is supported by the fact that

R. 24 gives a very similar picture, with the only difference that, while the cultures of R. 235 were 54 hours old, the culture here

Sib at 16.3 hours and is killed at 60-70 seconds. 36031/2"

„ „ „ „ 50-60 „ indi

Incidentally, the same reasoning applies here as for R. 23.

Photo R. 25, on the other hand, shows a completely opposite picture; but since the culture was infected with a foreign bacterium, one probably shouldn't put much stock in this series

R. 31 compares the effect at 45° with that at 30°. Even if we disregard No. 12, which is possibly a "coincidence," we still get a faster effect at 45° than at 30°.

At 45°, the limit is between 20 and 40 seconds. 300 40 Furthermore,

„ the „ „ „ „ „ „ 60 „

is much greater at 45° than at 30°, and while the growth at 30° is diffuse (+), at 45° it is "scattered" (s) (cf. p. 81).

R. 32 gives completely corresponding results:

At 45°C, the limit is between 20 and 40 seconds. 300

150 40 60 „ „ „ „ 90 „ too, „

„ 60 „ „ „ „ Here, „

greatest at 45°C.

R. 34 simultaneously examines a 5-6 hour old and an 8-9 hour old culture at different temperatures.

5-6 hour old culture:

At 45°C, the limit is between 40 and 60 seconds. 300

„ 150 „ „ „ „ hour „ 60 „

„ 60 „ „ „ old and

culture: 100 150 At 45°C, the

100 seconds.

„ 100 „ „ „ „ 150 „ „

„ 100 „ „ „ „ 150 „

Here, too, we see the dilution occurring earlier and more strongly the higher the temperature.

Since in the last three series of experiments, which, incidentally, are the ones just discussed that were carried out with the greatest precautions, one always began with the highest temperature and examined the lowest last, one could theoretically object that if the bacteria illuminated last in each series were the most resistant, this circumstance could be

due to the fact that they had aged about an hour while the first ones were illuminated; in other words, that the result was a consequence of age and not of temperature. Although a comparison with the corresponding ages in Plates I and II (pp. 87-88) will immediately convince one that, in any case, the effect of 450 cannot be explained in this way, I have nevertheless carried out some direct experiments to investigate the justification of this objection, namely:

R. 36, where the experiments at the low temperature were carried out before those at the high temperature. It turned out that the kill limit for one culture at 15°C (4 hours old) was between 70 and 100 seconds. 300 450 4-20 " " 4.40 " and 30 20 50 40

„ 17 The „ two „ 30°C „

„ last intervals (20-40 and „ but „ all „ „

drops gave growth after 30 seconds, whereas at 45°C 3 out of 4 drops were sterilized after 20 seconds

For the second culture, the kill limit was 150 (age 9 h) 300 450 > 170 sec. > between

„ 170 „ the 80-100 sec. „

„ 9.40, „ 9-20 19 In this series of experiments,

dilution was also stronger at 450.

According to these experimental results, there can be no doubt that Prodigiosus is killed more quickly by light at 450 than at 300, and as a result of Rs. 23 and 24, it is likely that it is killed more quickly at 350 than at 16-180. Whether, however, there is a difference between illumination at 300 and 150 remains doubtful. Series 32, 34, and 36 do indeed speak in favor of a greater effect at 30° than at 15°, but when compiling the remaining figures, Medical

series of experiments, the picture is so blurred that one cannot yet make a definite statement about it. For example, after these experiments, one cannot rule out the possibility that there is an "optimum" lying somewhere between 150 and 300.

This influence of temperature is of interest from two different points of view. First, from a biological point of view. As the control experiments (R. 35) unanimously state, Prodigiosus suffers no visible damage when exposed to a temperature of 450 for as short a time as my experiments lasted; nevertheless, it is killed more quickly by light at this temperature. Whether increased oxidation is to blame for this, I do not know at present

Secondly, these relationships could possibly have practical significance. Should later experiments show that pathogenic bacteria behave in a similar way, one would have to ensure during light therapy that the affected area of skin is not cooled more than necessary so that the patient is not bothered by the heat rays.

Although I do not expect other researchers to find exactly the same absolute values as I did in the above experiments, because so many other, partly still unknown factors in the living conditions of the bacteria.
can become important, I nevertheless believe that it is not without significance to be able to establish certain numerical data that apply under specific conditions. I have thus found that under the influence of light located 28 cm from an electric arc of 35 amperes and 50 volts, at an angle of 450 with the axis of the carbons, after a portion of the heat rays has been retained by a 25 mm thick water

layer between quartz plates, and at a temperature of 30°C, a 3-hour-old Prodigiosus broth culture in a hanging drop is sterilized in about one minute, while a 10-15-hour-old culture only takes 3-5 minutes. At 45°C, the light acts faster than at 30°C, so that a 3-hour-old culture is sterilized in about 1/2 minute. Without careful consideration of the age of the culture and the temperature, one cannot expect consistent experimental results, because these two factors together can cause the killing time to be ten times longer in one case than in another.

Copenhagen, November 1899.

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II. The Actinoscope by Absalon

Larsen.

The light-collecting apparatus of the Light Institute is known to be equipped with rock-crystal lenses and combined with a layer of water that absorbs heat rays

The institute has now given me the task of constructing an apparatus with which it can be easily and quickly determined whether the light concentrated by the collecting apparatus contains ultraviolet rays, or whether these have been absorbed, which should not be the case with good apparatus. I have called the apparatus constructed for this purpose the actinoscope. The basis of the apparatus is the phenomenon observed by Hertz that ultraviolet rays promote the generation of electrical sparks. For example, if sparks are formed between a platinum plate and a small brass sphere using a small Ruhmkorff inductor, then the electrodes can be separated significantly further from each other without the sparks ceasing when the platinum plate serving as the negative electrode is irradiated by ultraviolet rays than when this is not the case.

A dry cell and a Ruhmkorff inductor are located in a wooden box (24 × 26 × 26 cm). The

Electrodes are located in a small wooden box (8 × 8 × 17 cm) (Fig. 1). Electrodes a and b are connected to the secondary windings of the inductor by means of well-insulated wires. For convenience, the main current is conducted through an interrupter (not shown in the figure) attached to the small box. The negative electrode a consists of a 2 cm diameter platinum-plated brass plate. The positive electrode is a brass rod b, which can be moved away from or closer to the platinum-plated plate by means of a hard rubber screw head e. The light enters through the opening O and strikes the platinum-plated plate

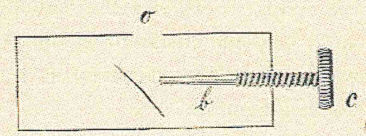


Fig. 5.

The experiment is carried out as follows: The small box is held in the hand so that the platinum plate is in shadow. The main current is closed, and the brass rod is first brought close enough to the platinum plate to produce sparks, and then turned back slightly so that the sparks cease. The box is then held so that the rays to be examined, coming from the collecting apparatus, strike the platinum plate through the opening. If ultraviolet rays are present, lively sparks will immediately arise, which will cease just as quickly if the platinum plate is placed in shadow, or if even a very thin glass plate is held in front of the opening. For control purposes, one checks whether the unconcentrated rays coming directly from the arc lamp can produce sparks.

It is never difficult to decide whether the rays are effective or not. The sound of the sparks is very definite if ultraviolet rays are present. The whole process proceeds

so easy and so fast that 10 collecting apparatus can be tested with the actinoscope in less than 10 minutes.

The institute's collecting apparatus were tested with the actinoscope. Any defects present mostly resulted from contamination in the water layer. In two cases, it was found that the hydrochloric acid used to clean the collecting apparatus had not been rinsed away with sufficient care. In other cases, the contamination absorbing the ultraviolet rays came from the putty used to attach the lenses. In all cases, the apparatus were put back in working order after being rinsed and filled with fresh distilled water. Ordinary water absorbs the rays acting on the actinoscope

As can be seen, the actinoscope can be useful in some cases, although it only provides qualitative and not quantitative results. The rays acting on the actinoscope are located quite far in the ultraviolet region, as can be seen from the fact that they are absorbed not only by glass, but also by very dilute hydrochloric acid, by insignificant inorganic impurities, and by ordinary water.

Since virtually all substances that absorb ultraviolet rays, in small quantities, only cut off the rays furthest in the ultraviolet spectral region and only in larger quantities also absorb the rays closer to the visible spectrum, the actinoscope test can be regarded as a strict test. If the rays act on the actinoscope, one can safely assume that the collecting apparatus is in order with regard to absorption.

Regarding the phenomenon discovered by Hertz, which is put to practical use here, reference should be made to the comprehensive

Investigations by Wiedemann and Ebert[1]) are referred to. From these it follows that the phenomenon is complex and varied, depending on the shape and nature of the electrodes and the type and pressure of the air. In particular, it should be noted that irradiation not only increases the spark length, but also completely changes the character of the discharge.

While working with the actinoscope, I noticed a special circumstance which, to my knowledge, had not been observed before. It turns out that, due to the action of the direct rays of an arc lamp, the discharge occurs most vividly at a certain distance from the lamp, while it ceases both when the apparatus is moved far away from the lamp and when it is brought very close to it

In the latter case, the sparks reappear, either when a screen with a small opening or a layer of water is held in front of the lamp. Light concentrated by a rock-crystal lens onto the platinum plate, on the other hand, had a very strong effect. However, at the time this communication was being written, I have not had the opportunity to investigate this phenomenon more closely.

It should also be noted that the effect of ultraviolet rays on electrical discharges has recently been used for telegraphy.

1) Annalen der Physik und Chemie 33, p. 241 and 35, p. 209, 1888. 2) Elektrotechnische Zeitschrift 19, pp. 414, 481, 826, 1898

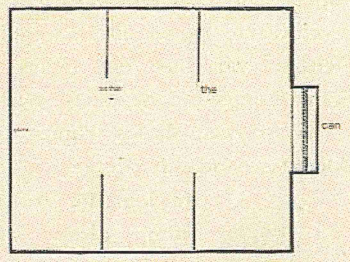
III.

A photometer. By Absalon Larsen.

To measure the intensity of concentrated light, I have constructed the apparatus described below

Some broken rock crystal lenses were crushed into fine sand, which was then suspended in water. What remained suspended after a few minutes was dried and then formed a very fine white powder. This powder was pressed between two rock crystal plates set in a brass ring. The whole now formed a milk-colored plate, which was attached via a round opening to one side of a square wooden box, matte black on the inside and provided with blinds, shown in Fig. 1. a is the milk-colored rock crystal plate, b, b are two blinds with openings the same size as the plate. On the side of the box opposite the plate, which can be opened, a freshly prepared piece of silver chloride paper is attached. Plate a, provisionally closed with a lid (not shown in the figure), is placed where the light is concentrated, and the lid is removed. After

After a certain time, measured with a chronograph, approximately 3 minutes, the lid is placed back over the opening. The silver chloride paper is then blackened, and from the degree of blackening of the paper, the intensity of the light can be determined, as described below. By using the rock crystal plate described, the light is attenuated to such an extent that the time required to produce a suitable blackness becomes so long that it can be measured accurately, whereas with direct irradiation with concentrated light, the paper is blackened in a very short time. On the other hand, the attenuation of the light is not associated with absorption of ultraviolet radiation, which would be the case if an ordinary frosted glass plate had been used. The effect of the fine rock crystal powder on light must be understood as follows: the rays striking the powder, after numerous reflections and refractions, leave the powder again as diffused light in all directions, regarded as a new light source The presence of ultraviolet rays in the diffuse light emanating from the rock-crystal plate under the circumstances mentioned has been confirmed using the actinoscope described above.



be

The use of photographic paper to measure the chemical intensity of light is a very common procedure, employed, for example, by Roscoe and Wiesner (see Mitteilungen des Instituts I, p. 109, 1900). The aforementioned researchers compared the color of the surface with

of the paper with suitable standard colors. However, there is no simple relationship between the surface color and the amount of light. Therefore, preliminary experiments must determine which amount of light corresponds to each of the standard colors, and afterwards, one must always ensure that the blackening of the paper is equal to that of a standard color, since the eye is not capable of quantitatively estimating color differences. I have therefore dispensed with the use of standard colors and, following Dr. Bang's advice, devised a new method that consists of observing the blackened paper in continuous light. Imagine a piece of exposed paper whose degree of blackening is to be determined.

this paper is placed close to an unexposed piece of the same type of paper, and if the two pieces are exposed to the same intensity at the back in a darkroom, with a light intensity of 1, then, viewed from the front, they will not appear equally bright In Figure 7, a represents the unblackened paper and b the blackened paper. By amplifying the light falling on the back of paper b, it can be achieved that b appears as bright as a. If the necessary light intensity is, for example, 4, while paper a is exposed as before with light intensity I, then I will set the degree of blackening of paper b equal to 3; for if paper b had not been blackened, then light intensity I would be sufficient to make b appear as bright as a; now light intensity 4 is necessary for this; light intensity 3 has then been retained by the silver particles deposited in the paper. Experiments have shown that the degree of blackening determined in this way is at least up to a degree of blackening 2 with

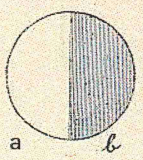


Fig. 7. If

is proportional to the amount of light that caused the blackening. It is therefore more rational to observe the paper in continuous light than to judge the surface color, and the difficult use of standard colors can be dispensed with.

The measurements are carried out with the apparatus shown in Figure 8. C is a double prism according to Lummer and Brodhun 1), D is a magnifying glass. The double prism is ground in such a way that one can look through a certain section of the contact surface of the two halves and thus observe the piece of paper a, while at all other points of the contact surface total reflection occurs, so that one sees the piece of paper b there. a and b are illuminated with two incandescent lamps A and B, which can be moved on two rails provided with graduations. Since one cannot assume that the two incandescent lamps have exactly the same luminous intensity, the experiment is carried out as follows B is placed at a certain distance, e.g., 100 cm, from the unblackened piece of paper b, and A is shifted until the two fields seen in the prism appear equally bright. Now, the blackened piece of paper to be measured is inserted in place of b. To restore equality of the D

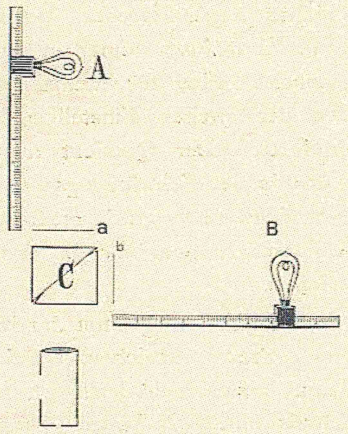


Fig. 8.

1) Zeitschrift für Instrumentenkunde 1892, page 41.

To achieve two fields, one must move B closer to the prism, say to a distance of 50 cm. The luminous intensity of the light falling on b is now 1002 = four times 50 greater than (before; / of) the degree blackening is therefore 3. The luminous intensity of incandescent lamps varies considerably with the operating voltage. This is of no importance, however, if the two lamps are identical and fed from the same line. For convenience, the first adjustment is always made at the same distance. A table calculated for all times then gives the blackening degree corresponding to the second adjustment. The quotient of the exposure time in minutes to the blackening degree gives the luminous intensity. If the blackening degree of several pieces is to be determined, one only needs to make the first adjustment once

With practice, the adjustment can easily achieve an accuracy of 1/2 percent. The difficulty of the method lies in the fact that it is not always easy to have paper of the same sensitivity. However, the same difficulty also applies to the older methods. I have always used Rives raw paper and prepared it myself. Pieces the size of a quarter sheet are placed in a 3 percent NaCl solution for 5 minutes and then hung vertically to dry. After drying, the lower part of the paper, which contains more NaCl than the rest, is cut away. The paper, thus salted, is placed in a 10 percent AgNO3 solution for 3 minutes one day before use and then rinsed three times in pure water for one minute each time, after which it is hung in a darkroom to dry.

The method described here for determining the degree of blackening of photographic paper has been used, among other things, to measure the absorption occurring in agar and broth. Furthermore, the same method has been used to determine the dependence of the photochemical intensity of arc light on the current and voltage, as shown below.

September 14, 1899

IV.

The Dependence of the Electric Arc Light on the Current and Voltage by

Absalon Larsen.

In order to obtain an idea of the nature and magnitude of the changes in the electric arc light associated with changes in current and voltage, I made some measurements of the light intensity, partly with a bolometer and partly with photographic paper. A glass plate was placed in front of the bolometer to absorb heat rays, so that the bolometer measurements approximately indicate the total amount of energy of the visible rays converted into heat, while the measurements with photographic paper, whose degree of blackness was determined in the manner described above, provide an approximate measure of the intensity of the violet rays

The numbers given under "Bolometer" in the following table have been converted so that they indicate how many gram calories per second the rays falling on the bolometer would develop in the bolometer if the bolometer were at a distance of 1 meter from the crater and the surface of the bolometer were one square meter in size. The numbers given under "Photographic Paper" are calculated from the degree of blackening as follows: The degree of blackening,

which in all experiments was between 0.5 and 1, was divided by the exposure time in minutes and multiplied by the square of the distance from the crater expressed in meters. The resulting numbers, which indicate the degree of blackening corresponding to an exposure time of 1 minute and a distance of 1 meter, were then multiplied by 100 so that they could appear as whole numbers

The hand lamp				The shunt lamp			
Ampere	Volt	Bolom.	Photographic Paper	Ampere	Volt	Bolom.	Photographic Paper
7.7	40	7.2	13.3*)	18.5	approx. 50	32.1	62.2
7.6	45	9.3	15.4%	23	„ 50	39.3	125
7.6	50	9.4	15.5	27	50	47.0	98
7.6	55	9.9	15.1%)	30	"50	47.5	165
7.8	60	10.5	15.0%)	35	„ 50	55.8	185
5.3	50	6.9	11.5	39.5	„ 50	61.0	196
6.9	50	9.0	15.2	47.5	„ 50	69.6	324
8.2	50	10.8	24.0	18.5	approx. 50	28	77
11.5	50	14.5	47.2	26.5	„ 50	41	128
13.6	50	17.4	59.2	31.5	„ 50	48	183
7.3	50	9.2	14.2	36.5	„ 50	53	204
8.0	50	11.6	22.7	43.5	„ 50	63	276
10.5	50	14.6	37.0				
12.8	50	17.9	56.1				
15.9	50	21.8	84.1				

I measured the light from a small lamp with manual regulation and carbons of 14 mm and 11 mm diameter and that from a large self-regulating shunt

*) Average of three series of measurements

lamp with carbons of 24 mm and 15 mm diameter. In all experiments, the rays used formed an angle of 450 with the axis of the carbons, and both the bolometer surface and the paper were positioned perpendicular to the rays.

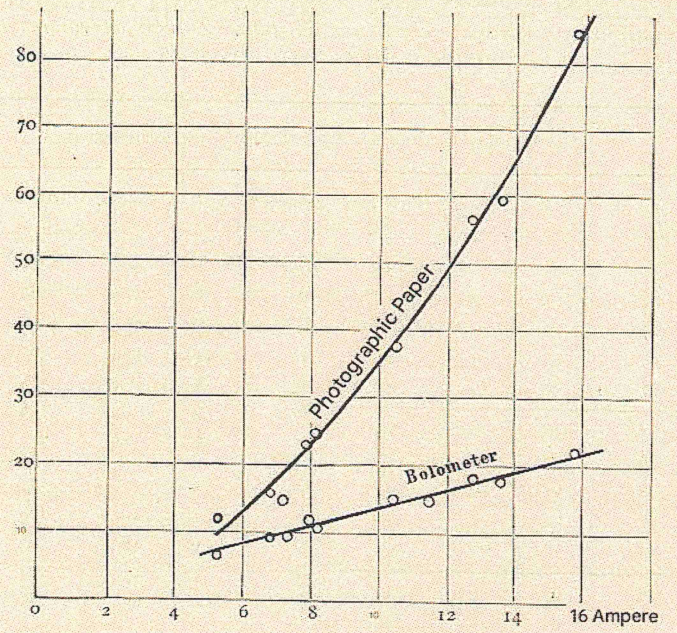


Fig. 9.

The dependence of light intensity on voltage has only been investigated with the hand lamp. At 40 volts, both the thermal effect and the photochemical effect are significantly smaller than at the other voltages. Between 40 and 60 volts, both are to be considered independent of the voltage; but even at a voltage of 60 volts, the lamp no longer burns steadily, and various

experiments at this voltage differ considerably from one another

Two series of experiments were conducted with both lamps at a voltage of 50 volts to determine the dependence of light intensity on current strength. The test results are shown graphically in Figures 1 and 2. The observations are marked by small circles. Curves are inserted between the observations. In Figure 1 (the hand lamp), the deviations between the observations and the curve are generally small, from which one can see that the lamp burned steadily. Larger deviations occur in Figure 2. These arise mainly from the irregularities that arise whenever the regulating device is operating, at least when, as in my experiments, voltage regulation is left to the automatic regulating device alone

The heating effect of the hand lamp is proportional to the current, that of the shunt lamp only approximately. The photochemical intensity, however, increases much faster than the current in both cases. In other words, as the current is increased in a given lamp, the intensity of the violet end of the spectrum increases much faster than that of the red end. For the hand lamp, for example, at 8 amperes, the ratio between the numbers expressing the photochemical intensity and the heating effect is 2, whereas at 16 amperes the ratio is 4. For the large lamp, the ratio is 2.7 at 24 amperes and 5.7 at 48 amperes.

A comparison of the two lamps is best made at currents that are related to the cross-sections of the positive carbons. At 12 amperes, the small lamp gives a heating effect of 16 and a photochemical effect of 49. The large lamp, whose positive

Coal has three times the cross-section, at 36 amperes gives a thermal effect of 56 and a photochemical effect of 198. The ratio of the current intensities is 3, the ratio of the thermal effects is 3.5, and the ratio of the photo-

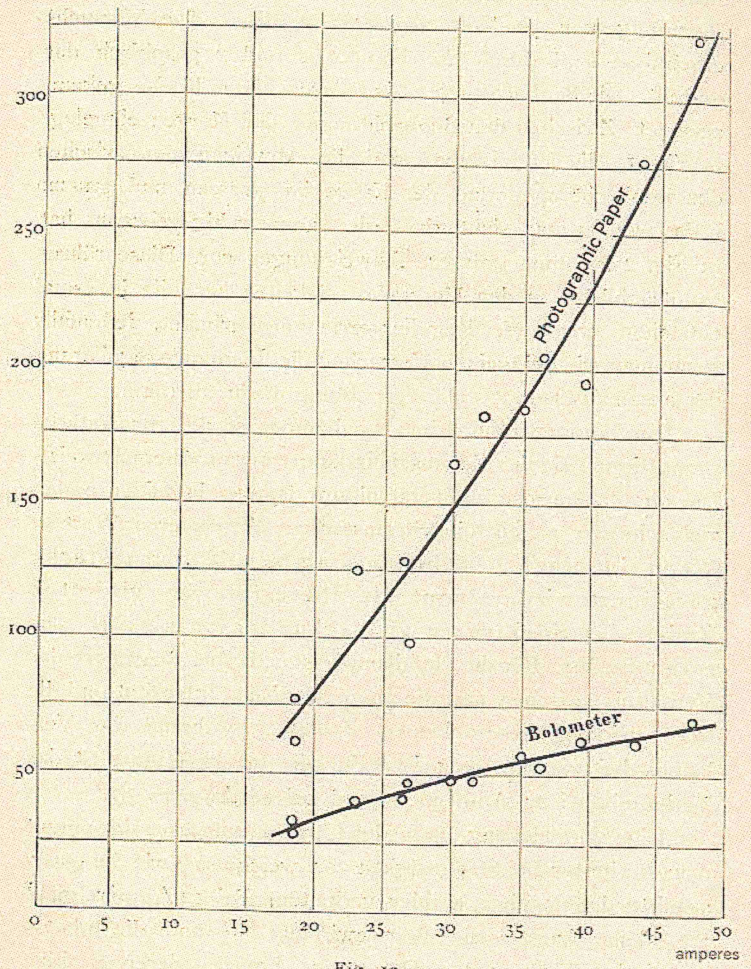


Fig. 10.

chemical effects is 4. Thus, at the same current density, a large lamp is a little more economical than a small one, and the light from a large lamp is a little more developed in the violet spectral region than that from a small one

It is not difficult to see that the results must point in this direction, because an increase in current density and a simultaneous increase in the carbon cross-section must produce a larger crater and a higher temperature, which in turn causes an increased radiation and a shift towards the violet. The experiments reported here can only be regarded as orienting. For an exhaustive investigation, spectral apparatus would be necessary with the help of which the intensity of the radiation could be measured in all spectral regions.

September 27, 1899.

Diakeroioiol The Light as Incitament

by Prof. Dr. Nils R. Finsen.

This treatise is not reproduced in the German edition, as it appeared earlier in Prof. Finsen's book: "On the Significance of the Chemical Rays of Light for Medicine and Biology."

Lupus vulgaris laryngis. A clinical investigation by

Prof. Dr. Holger Mygind

This treatise is not reproduced in the German edition because it appeared earlier in the Archiv für Laryngologie, Vol. X

V.

Report from Finsen's Medical Lys Institute.

From January 1 to December 31, 1899.

The following annual report is of only local interest in many respects, but is reproduced here partly for the sake of completeness, and partly because it provides some clarification on the development of the Light Institute.

I.

By Prof. Dr. Niels R. Finsen.

The institute's first annual report covered the period from August 1896 to December 31, 1897. The current annual report covers the two years from January 1, 1898, to December 31, 1899.

I can begin this annual report, just as I did the previous one, by saying that what we are reporting here is not a quiet, steady activity, but one in continuous and rapid development that is far from at rest

The work of the Institute for the Matter of Light (the demonstration of the application of light in medicine and the efforts towards recognition in the medical world) has grown steadily, and especially in the course of the last year, the practical work, i.e., the treatment of patients, reached a provisional culmination already at the end of 1898, since the limited space did not allow any further increase in the number of patients, so that there was no other advice than to temporarily turn away a large number of patients. At a certain time of the year, the number of registered patients was well over 100. We sought to remedy this inconvenience by

treated the most needy patients first; moreover, there was a reasonable prospect of such an expansion of the institute that all legitimate claims could probably be satisfied. This was made possible by the large grant of 240,000 crowns, which was granted to the institute as an interest-free loan under the Finance Act of 1899-1900, as well as by the finally made possible acquisition of the property in the villa district "Rosenvaenget," already mentioned in the previous annual report, which in every respect, both in terms of its buildings and its grounds, is eminently suitable for the institute.

While the future of the Light Institute seems to be well secured in economic and material terms, it was at the same time important to me to provide the institute with the greatest possible security through a strong internal organization, especially with regard to intellectual resources

Since it is dangerous for any institution to depend exclusively on one person, I sought to avoid this at the Light Institute by giving each department of the institute, the laboratory and the clinic, a completely independent and responsible director. The management of the laboratory has been taken over by my long-time collaborator and friend, Dr. Sophus Bang, whose scientific abilities and critical talent will be of the greatest importance for the Light Institute, and whose task in the coming years will be to take over the leadership of scientific-physiological investigations in the field of light.

The management of the clinic was given to Dr. Holger Forch.

Dr. Bang is currently an assistant physician at the municipal hospital and will therefore not be fully at the service of the Light Institute for another 1.5 years

Hammer, who joined in February 1898, was appointed senior physician at the end of 1899. His administrative talent and practical ability have brought the institute great benefit under often difficult conditions. 2

In this way, the laboratory and the clinic, which were initially united, have been completely separated; however, I hope that the separation will primarily be beneficial and not harmful. Since the two departments will be located next to each other on the same property, and since the head of the institute will form a link between them, the conditions for the necessary cooperation will be favorable. On the other hand, the field of work for both departments is so large and so diverse that the separation was absolutely necessary

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As before, the institute has received numerous visits from doctors, some Danish, some foreign. The visits from foreign doctors must be considered of great importance as an excellent means of spreading interest in light treatment; for while the light institute and light treatment had long enjoyed the greatest recognition from Danish and Scandinavian doctors, the same could not be expected from foreign doctors. Indeed, it is not surprising that the medical world received the reports about the remarkable effects of chemical rays with a certain suspicion, whether because they are harmful, as in smallpox, or beneficial, as in lupus. Furthermore, the fact that these things appeared in a small country, distant from the great center of science, and originally in a language known only to a few, was of no small importance.

The visits from foreign doctors were of two kinds::

Some came from doctors who were just passing through Copenhagen and thus took the opportunity to see the Light Institute; others from such doctors, mainly dermatologists, came exclusively for the purpose of the matter itself. The latter stayed for shorter or longer periods of time in order to study the method thoroughly. In this way, we had the honor and the pleasure of receiving several of the greatest and most well-known dermatologists in Europe.

A complete list of the places where the method was introduced and applied is not easy to give; one can only get an approximate overview by looking through the list of places to which the manufacturer of the institute sent light-collecting apparatus. The numbers in parentheses after the name of the city mean that the corresponding number of apparatuses were delivered to doctors or hospitalers.

Athens	London (3)
Baltimore	Moscow
Berlin (2)	Munich
Breslau	New York
Budapest	Paris (2)
Dortmund	St. Petersburg (4)
Hamburg (3)	Washington
Cairo	Vienna (4)
Cologne	

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1) During the course of 1899, a change occurred regarding the sale of light-collecting apparatus, in that the firm W. A. Schiörring, Reventlowsgade 10, received a trademark for the apparatus in my name in most countries. Exclusive distribution of the apparatus has since been transferred to the aforementioned firm, while the apparatuses, as before, are manufactured by Mr. Warberg, the plumber. All apparatuses are tested in the Institute's laboratory before shipment

The great interest and favor shown by members of the Danish royal family in the institute and the cause of light have been of the greatest importance for the spread of light treatment and its penetration into certain other European countries. In January 1898, we had the honor of a visit from HRH the Crown Prince for the first time, and later he showed the greatest interest in the Light Institute, its work, and its patients. Since then, the Light Institute has had the honor of being visited several times by members of the royal family and their imperial and royal guests. These visits have had the significance of introducing light treatment to the three countries of Greece, England, and Russia earlier and in a better way than would otherwise have been the case. Her Majesty Queen Olga of Greece donated apparatus for sunlight treatment to the Evangelismos Hospital in Athens and furthermore had a Danish nurse trained at the Light Institute HRH The Princess of Wales donated a complete set of equipment for treatment with sunlight and electric light to the large London Hospital. As a result, the senior physician of the hospital's dermatological department, Dr. Stephen Mackenzie, came to Copenhagen to study the method for about a week. Two nurses were later sent here from the hospital and completed a one-month course.

HRH The Dowager Empress Maria Feodorovna of Russia introduced the method there and made it known to the Russians in the best possible way. Her Majesty wished to establish an institute in St. Petersburg entirely on the model of the local institute and made all resources available so that both a scientific department

(laboratory), as a clinic were established. To convince the medical world in Russia of the importance of the matter, Her Majesty sent the surgeon Prof. Veliaminoff, with his assistant, Dr. Serapine (who now heads the Light Institute in St. Petersburg, assisted by a Danish nurse), to study the method. Furthermore, the Empress summoned Prince Oldenburg (the supreme chief of to Russian medicine) to Copenhagen, along with three Russian von scholars: Prof. Lucianov, Director of the Imperial Pathological Institute in St. Petersburg, Tchistovich, Professor of Infectious Diseases at the Imperial Military Medical Academy, and Dr. Botkin

As a result of these visits, a series of medical lectures were held in St. Petersburg on the light method, some with demonstrations of slides based on photographs from the local institute; several treatises were also written on the subject. In this excellent manner, the light method was introduced in Russia, and as a result, in no other European country, outside Scandinavia, is it as well known and recognized as in Russia.

II. The laboratory of Dr.

Sophus Bang.

Compared to all previous attempts to utilize the properties of light to cure diseases, the effectiveness of the light institute in Institute, is exceptional. II. our 9 Finsen, Medical Light

A special position, which is primarily due to the fact that the institute is based on scientific work in its plan and mode of action. On the basis of scientifically sound theories, Finsen began to use light for curative purposes; no less was the manner in which it was applied, even in the first uncertain attempts, based on physical and physiological experiments. Otherwise, the Light Institute, even with the most successful cures, would not have achieved the leading position it now indisputably occupies in the field of light therapy. Proceeding from this, an ever-increasing interest in both scientific and practical experiments with light has arisen throughout Europe, a movement through which the parent institute in our country perhaps runs the risk of being overshadowed by the institutions already flourishing in many large cities. Admittedly, the Light Institute currently possesses so much fundamental experience that it has a good head start; Whether it will succeed in maintaining its leadership in the future will depend on whether it will also be able to assert its scientific superiority. Fortunately, the importance of this matter was clear to the directors of the institute from the very beginning, as is evident from the first paragraph of the statutes: "The task of the institute is to conduct and promote investigations into the effects of light on living organisms..." To promote these investigations, the institute was divided, as soon as the general status permitted, into an experimental laboratory department and a clinic, each with its own independent director, and ample financial resources were placed at the laboratory's disposal by the institute's management.

A quite significant body of research has been

already done in the laboratory; apart from the results already published, however, a great deal of preliminary work had to be carried out, and on a scale that could not have been foreseen in advance. Although so much has already been written about the effects of light on the animal organism and on bacteria, one very often had to work on previously completely uncultivated ground; only a fraction of the earlier work was carried out in such a way that one could rely on the results. Almost every question had to be addressed from the ground up; not only how to create a light with the desired properties, but also how it should be regulated, controlled, and measured; what properties the applied light had, and what sources of error were inherent in its use—a multitude of such technical details had to be investigated before one could know anything at all about the effects of light. And although we now have much more insight into these circumstances than a few years ago, in many respects we are still aware that we are only at the beginning: everything we have published so far can be regarded only as preliminary work

Of major, as yet unpublished, works that have occupied us over the last two years, we can mention: Investigations into the influence of light on metabolism, with the development of new methods for determining it. The effect of light on tubercle bacilli investigated by means of animal experiments. The effect of concentrated light on living tissues. The influence of light on food substrates. Of smaller works, we can mention: The construction of electrical resistors, particularly suitable for experimental use. Experiments to increase the content of arc light in chemical rays. Light measurements. Investigations into the

Functionality of the equipment used in the clinic. Checking the equipment ordered for export. Microscopic examinations for the clinic. Various bacteriological investigations.

Holger Forchhammer's

clinic.

In 1898 and 1899, as in previous years, the work at the clinic consisted predominantly of the treatment of lupus vulgaris, as the influx of patients with this disease was constantly increasing.

In addition, as space permitted, experiments with the treatment of other skin diseases continued, among which lupus erythematosus, alopecia areata, epithelioma cutaneum, acne vulgaris, acne rosacea, and nevus vascularis planus must be mentioned first and foremost

After the number of light apparatuses was increased from 8 to 16 in November 1897, the number of patients rose very rapidly. While in December 1897 the daily number of individual treatments was less than 50, it had reached 100 by April 1898. A further increase was made possible by the installation of four new light apparatuses in October 1898. For the whole of 1898, the average number of individual treatments per day was 99; for 1899 the number was 126.

The number of new patients admitted was 219 in 1898 and 289 in 1899.

In addition, of those admitted in 1896-97,

88 patients were here for continued or renewed treatment, bringing the total number of patients treated in 1898-99 to 596.

Lupus vulgaris: a total of 454 patients were treated, of which 73 were transferred from 1896-97, 162 were added in 1898, and 219 were added in 1899.

Of the 381 new arrivals, the following were:

males in 1898: 42, 1899: 56, a total of 98; females: 120, 163, 283 „ „

The age of the patients was:

0-15 years:	. . . .	1898: 15,	1899: 26,	a total of 41
15-25:	„	„ 64,	„ 66 ..	„ 130
25-40 52,	„		„ 72,,,	„ 124
40-60 23,	. . . .	„ 48,	„ 71 „	„
60-70 "	. . . .	„ 7,,	„ " 15	

From Denmark were 1898: 155, 1899: 187, total: 342

From abroad were 7, 32, „ 39 „ „

From the Danes were:

from Copenhagen	. . .	1898: 33,	1899: 31,	total: 64
„ and the rest of Zealand 18,		„ 26,	44 „	„
„ Jutland	. . . . .	„ 81,	„ 11, „	„ 182
„ Funen	. . . . .	„ and	and 12	„ 14, 26
„ other islands II,	.	„ 15,	„ 26 „	—

Of the foreigners were:

from Schleswig	. . . . .	1898: 3,	1899: 9,	in total: 12
„ rest of Germany	.	„ I,	„ I, „	„ 2
„ Sweden 3, 9	. . . . .	„	„ 6, „	„
„ Norway 7, 7 "	. . . . .	„ —,	„	„
„ Russia 3, 3	. . . . .	„ —,	„ - „	„
„ Finland	. . . . .	„ —,	„ 2, 2	„
„ England	. . . . .	„ —,	„ 3, 3,	„ 19
France " I,	. . . .	—,	„ „	I

The duration of the patients' illness before treatment was as follows:

0-5 years	. . . .		1898: 34,		1899: 67,		total: 101	
5—10	,,	. . . .		45,	,,	50,		95
10—15	,,	. . . .	,,	34,	,,	45,	,,	79
15—20	,,	. . . .	,,	24,		21,	,,	45
20—25	,,	. . . .	,,	13,		20,	,, ,,	33
25—30	,,	. . . .	,,	6, 5,		11	,,	
30—35	,,	. . . .	,,	3,	,,	5, 8	,,	
35—40	,,	. . . .	,,		,,	1, 4,	,,	5
over 40		. . . .	,,	2,	,,	2, 4	,,	

Of all 454 patients treated for lupus vulgaris, 121 were still under continuous treatment at the end of 1899, 307 had "finished the main treatment," while 26 had discontinued treatment at an inopportune time.

Of the 26 who discontinued treatment, 10 had died (7 from pulmonary tuberculosis, 1 from canker sore ulcer in lupus, 1 from pneumonia, 1 after a laparotomy), 5 stopped because of pulmonary tuberculosis gravis, 5 had to leave due to personal circumstances unrelated to treatment, 4 left us to continue the light treatment at home, and finally, 2 stayed away without giving a reason

While lupus patients had been treated exclusively with light in previous years, in 1898-99 we used various other treatment methods as preparatory or supportive measures in some cases. Thus, we performed scraping or thermocautery in individual cases. More frequently, caustic ointments, usually Ungv. ac. pyrogallici comp. (Besnjer), were used. During light treatment, almost all patients wore a protective

dressing, either a compress of boric water or an indifferent ointment.

The numerous mucosal locations, which were largely inaccessible to light treatment, required special treatment Mygind did the institute the service of from Prof. Holger. examining 200 of the patients and kindly undertook the treatment of the incident cases of lupus laryngis

The frequently occurring eye diseases are kindly treated at the Eye Diseases Clinic of the Municipal Hospital (Dr. med. Ejler Hansen and Dr. med. CHR. F. Bentzen).

Other complications often required special treatment, and the institute's physicians occasionally supervised the patients at home. We also exercised a certain degree of supervision over the larger and smaller boarding schools established specifically for the institute's patients.

Erysipelas and erysipelas-like cases have occasionally occurred, but only as isolated cases.

No diseases have occurred epidemically among the patients.

As before, Prof. Haslund kindly helped to make the diagnosis in doubtful cases.

Finally, it must be mentioned that some of the institute's lupus patients were kindly treated by Dr. Johan Fischer, partly in the Municipal Hospital, partly in his private clinic

Other diseases: In the years 1898-99, a total of 142 patients with other diseases were treated. Of these, 15 were transferred from 1896-97, 57 came in 1898, and 70 in 1899.

1. Lupus erythematosus: a total of 31 patients,

27 of them from Denmark, 2 from Russia, 1 from Norway, and 1 from Sweden.

Of the patients, 7 were men and 24 women, all over 25 years old.

At the end of the year, 11 were apparently cured, 10 were still under treatment, while 10 had discontinued treatment without result. Of the latter, one died with a sharp increase in the extensive suffering, one worsened significantly under treatment, and the others were only slightly affected.

The majority of the patients were treated exclusively with light; some were also treated simultaneously with other methods, most frequently with superficial galvanic cauterization.

2. Alopecia areata: a total of 29 patients, all from Denmark.

18 males, 11 females
Age: 0-15 years: 8 15-25
25-40 „
40-60 9 8 „
4

At the end of the year, 22 were cured, 1 was still under treatment, while 6 had discontinued without result, most after a treatment of only a few séances.

Almost all patients were also treated with antiseptic bath waters during the light treatment.

3. Epithelioma cutaneum: a total of 17 patients, all from Denmark.

Males: 7, females: 10. Age: 25-40 years: 1 40-60 7 60-80 9 9

At the end of the year, 8 were apparently cured, 2 were in marked improvement, and 7 had discontinued treatment. Of these, one had been treated for a long time under the diagnosis of lupus vulgaris. The large cancerous ulcer healed, but the condition quickly worsened again. One improved but died of an intercurrent illness. One was treated solaminis causa for a large facial ulcer.

4. Acne vulgaris and acne rosacea: a total of 15 patients, of whom 14 were from Denmark and 1 from Norway.

Males: 8, females: 7. Age: 14-25 years: 6, 25-40, 40-60, 5, 4

„
„

At the end of the year, 4 were apparently cured, 5 were significantly better, and 1 was still under treatment, while 5 had discontinued treatment without result

5. Naevus vascularis planus: a total of 10 patients, of whom 9 were from Denmark and 1 from Norway.

3 males, 7 females. Age: 0-15 years: 4, 15-25, 25-40, 3, 3

„

At the end of the year, one was apparently cured, 2 had discontinued treatment, and 7 were still under treatment.

6. Tuberculosis cutanea: a total of 7 patients: 1 ulcer of the tuberculus anguli oris, still under treatment; 3 cases of verrucose tuberculosis, of which 2 were cured, the third concluded without result; 3 cases of scrofulous gommages, which were not noticeably affected by the light treatment

7. Trichophytia capitis: a total of 6 patients, all children under 7 years of age.

The result was negative in 4 cases; in 2 cases, both recent and only slightly spread, recovery occurred.

8. Favus, 2 cases, both with negative results.

9. Seborrhoea capitis, 4 cases, all with negative results.

10. Eczema faciei and sycosis, 5 cases, all with negative results.

11. Ulcera luetica, 5 cases. The 2 cases that were treated for some time under a false diagnosis apparently improved; the other 3 cases were treated only for a short time and primarily for social reasons.

12. Keloid after vaccination, 1 case in a 6-year-old child; treated with negative results.

13. Pigment atrophy, 2 cases, with negative results

14. Various, a total of 8 cases of other illnesses where treatment was not fully completed. Among them was one case of chronic otitis and one case of urinary vesicle tuberculosis, treated using specially constructed apparatus, both without a clear result.

VI.

Investigations into the frequency of lupus vulgaris in Denmark

by Prof. Dr. N. R. Finsen.

Since, due to the large and continuous influx of lupus patients to the Light Institute, it would be advantageous for practical reasons to know the number of local lupus patients, we have undertaken to provide some clarification on this matter

In view of the scientific interest that such a study would have, we initially wanted to make it reasonably comprehensive; however, it soon became clear to me that the difficulties were so great, and the prospects of obtaining a reliable result so slim (a point I will demonstrate below), that I decided not to make the study more comprehensive than necessary for our practical purpose.

To obtain information about the number of local lupus patients, two approaches were possible: an inquiry to all physicians or to all pastors. If the first approach was chosen, the result would be highly inaccurate, for it is a fact that most lupus patients with long-standing lupus no longer seek medical help for their illness and are therefore not treated by physicians

are known. If the doctors had a specific topographical sphere of influence and knew all the people within this sphere, the ratio would be quite different. The latter applies better to the pastors, but on the other hand, there is the inconvenience that one cannot rely on the diagnosis. To obtain scientific, usable statistics, the pastors and doctors would have to work together, so that the pastors would locate the sick and the doctors would make the diagnosis. However, this question was not of such great importance to me that I should initiate such a large project and inconvenience so many people. On the other hand, it would be worthwhile to try this combined method of investigation in a limited number of pastorates, then to be content with that, and to draw a conclusion about the situation in the entire country from the resulting ratio

—

It was fortunate that some time before, the Light Institute had received a visit from a large number of pastors from various parts of the country who had come to Copenhagen for other reasons. In the hope that their visit had interested them in the matter and that they would therefore conduct careful research, we sent these pastors, as well as many personally acquainted ones—a total of 70 pastors1—a form to be filled out, in which the following questions were asked: 1) How many patients (names, ages) suffering from facial lupus are in the pastorate? 2) Has the diagnosis been made by a doctor?

65 pastors answered these questions, and the result was the following: In 31 pastors, there were no lupus

1) We chose almost exclusively pastors from rural pastorates, as they were probably much more likely to know all the residents of the pastorates than the pastors from the cities.

patients, in the remaining 34 there were 54 patients, and these were distributed as follows:

in 2	pastorates	4	patients
„ 2	„	3	„
„ 10	„	2	„
„ 20	„	1	„

The diagnosis had been made by a doctor in all cases, except for two. All the answers, for which I hereby express my sincere thanks, proved that the pastors had made great efforts to obtain precise information, and in many cases they had cooperated with doctors to find patients.

These investigations were conducted in March and April 1899.

Since I would like to have an expert opinion on the value that could be attached to these investigations, I turned to the State Statistical Bureau, and Director Rubin took up this matter with the greatest graciousness. He had the information collected examined and sent me the following statement on the result, with permission to use it:

"To shed light on the question of the number of local lupus patients, you collected some information from several clergymen in the countryside and asked me to what extent I believed that one could draw a conclusion about the whole from these scattered information.

Although a procedure such as the one you used can produce useful results, the material in the present case is too small and does not provide enough information on important points to be given any value. Nevertheless, I have made the calculation you requested, but after our discussion, we agree that it not only has no

scientific value, but that one should not, or even less, rely too much on it for practical use.

Of the 65 schemes sent, I eliminated 2, some of which concern cities (one with 0, the other with 2 patients), and I then distributed the remaining 63 as follows:

Number of rural pastorates surveyed		Number of patients	The number should be in proportion to the total
Zealand (including Bornholm)	12	10	10
Funen, Laaland-Falster	16	12	13
Jutland	35	30	29
Total:	63	52	52

The distribution is therefore fairly even, and the number of patients should therefore be 82.5 percent of the number of pastorates. There are currently approximately 1,000 rural pastorates, but since some of these are connected to a city or a trading center, the most correct estimate regarding the rural population alone is to count with approximately 950, and the number of lupus patients should then be 784

Since we have separated the rural population from the urban population here, the former can only be counted as part of the population of Denmark as a whole, and if you accept the 784 and assume that a corresponding ratio can be applied to the urban population, we obtain, as far as the latter is concerned, 523 patients. On the whole, your material, used in this way, should lead us to estimate the number of lupus patients in Denmark at approximately 1,300.

Although Director Rubin's judgment on the result

is so hopeless that it might seem most correct to leave the question alone, I will nevertheless add a few remarks and clarifications. The question is of the nature that it is impossible to obtain exact figures and a reliable result, but therefore one must not completely give up the attempt to get as close to the truth as possible.

The question here is whether the number 1,300 (approx. 1/2 per mille) is too large or too small. I must leave aside the two important questions: 1. whether the number of lupus patients was disproportionately large or disproportionately small in the pastorates studied, and 2. whether the incidence of lupus differs among the urban population and the rural population. However, I will point out that the number of lupus patients given for the 65 pastorates is definitely a minimum, since these are patients known by name and the diagnosis was made by doctors

While, as far as I know, no studies or clarifications on this question have been available from other countries, the recently (1900) published 30th to 31st volume of NEISSER'S: Stereoscopic Medical Atlas contains some studies by Prof. NEISSER on the frequency of lupus in Silesia in the preface, page VI.

Prof. NEISSER writes about this: "I can provide the following information on the frequency of lupus in Silesia (with almost 42 million inhabitants): I wrote to the 1,560 physicians in Silesia asking them to report all lupus cases known to them. Replies were received from only 1,060 physicians, reporting 709 lupus cases. It is not necessary to explain in detail that this number in no way reaches the number of lupus cases present in Silesia. Apart from the fact that over-

Since only two-thirds of the doctors responded, many lupus cases in the area in which they practiced will also have remained unknown to those who wanted to fulfill my inquiry.

If one now assumes that the doctors who did not respond could report a corresponding number of lupus patients, one would obtain the result that there are at least approximately 950 lupus patients among Silesia's 4.5 million inhabitants, i.e. barely 14 per thousand, while my number for Denmark was at least 1/2 per thousand.

Despite this large difference, one should not conclude that lupus is more common in Denmark than in Silesia, because, as I emphasized above, one will always receive a much too small number when inquiries are made to doctors

However, if we disregard these problematic figures and stick to what is available of a more reliable nature, we will see that the number of lupus patients from Denmark alone, for which we have already reported at the Light Institute, is greater than 14 per 1,000 (so far we have treated a total of 477 lupus patients from Denmark, plus 192 who were or still are registered.

If I add that the registration of new patients (but old cases) is still very high, it is hardly an exaggeration to conclude 1) that the remaining

1) Since there are now so many factors that can influence the number of registrations, one must be somewhat cautious about drawing conclusions from them. From the establishment of the institute, there was a constant and fairly uniform increase in the number of patient registrations until the first quarter of 1899. This was followed by a quiet, slow decline. In recent months, there has been some increase again, without, however, reaching the number of the first quarter of 1899.

The number of lupus patients in this country is not entirely small, and it will perhaps turn out that the main number that emerged from our investigations is not far from the correct one

The result of Prof. Neisser's extensive work, which cost both a great deal of money and time, is undoubtedly even smaller and even further from the truth than ours, and does not encourage similar comprehensive investigations here, especially since in a few years, if everything goes as it has so far, we will receive excellent statistical material on the frequency of lupus diseases in this country from the Light Institute.

When we conducted the investigations mentioned here, we had no idea of the frequency of lupus disease; when speaking with doctors, one could hear assumptions that varied from 500 to 5,000 cases, and if the uncertainty was so great, one must assume that something has been gained from our investigations,

VII.

Treatment of measles and scarlet fever with exclusion of so-called chemical light rays.

Review article by Valdemar

Bie.

In an article 1) on the treatment of smallpox with exclusion of chemical light rays, Finsen wrote the following:

"This treatment, however, is, as one can see, not specific for smallpox; it is a new therapeutic principle which, as I have already stated above, could possibly acquire a certain significance in other exanthematous diseases and skin diseases. In any case, it will be of great interest to gain clarity on the question of whether chemical rays have an influence on these diseases or not. Skin diseases are a special matter; on the other hand, such investigations in exanthematous diseases, e.g., measles, scarlet fever, and erysipelas, would be very easy to conduct and, moreover, would be completely harmless." "Such experiments could easily be carried out in any hospital for infectious diseases, e.g., by lighting a sickroom with red light and an-

1) N. R. FINSEN: On the harmful effect of chemical rays on the animal organism. Hospitalstidende No. 44, 1893.

illuminated with ordinary light and then observed to see whether there is a difference in the course of the disease; one could also hang red curtains over the windows for a few days and then allow the light to enter again in the usual way over the next few days." Since it is now established that the exclusion of chemical light rays definitely prevents suppuration in the smallpox blisters, it seems to me time to try treating other exanthematous infectious diseases with red light as well, and this all the more so since animal pathology knows of a general disease accompanied by exanthema that is dependent on light. When ruminants are fed buckwheat, the white animals exposed to the light develop symptoms of poisoning from a narcotic substance, as well as a vesicular skin eruption; the white animals kept in the dark, as well as the black animals, remain healthy

Of course, one cannot draw any conclusions about the influence of light on the course of other exanthematous infectious diseases either from the circumstances of this buckwheat disease or from the favorable results of smallpox treatment with red light; however, it seems to me that the experiences mentioned justify the attempt to apply Finsen's treatment method to these diseases as well. So far, this has only been done on a limited scale, with only seven series of experiments available.

Immediately after Svendsen published the first favorable results of smallpox treatment according to Finsen's method in Bergen, the district physician Birkerod tried treatment with red light in two scarlatina-like cases.

1) F. Birkerod: Reports from the Municipal Hospital in Nyborg. Ugeskrift for Läger 1894. p. 211. 10*

In both cases, the patients became free of fever a few days after being exposed to red light, even though no antipyretic was used at the same time, and even though quinine, antifebrine, and antipyrine had no effect on any of the patients. Dr. Birkerood, on the other hand, mentions no effect on the scarlatina-like rash that was present in both cases.

The question of the effect of red light treatment on temperature is very interesting, but it has not yet been the subject of any thorough experimental or clinical investigation. This question cannot be resolved by two cases, as Dr. Birkerood himself quite correctly saw, noting that one cannot draw any conclusions from these individual experiments, but that the favorable result nevertheless encourages the continuation of the experiments

THYMANN,1 who attempted to treat scarlatina patients with red light in the Copenhagen District Hospital, had a much better opportunity than BIRKEROD to assess the effect of red light on the course of the disease, insofar as he had 36 patients at his disposal. However, he focused his attention entirely one-sidedly on the course of the exanthem. He writes the following about his experiments: "36 patients (with scarlatina, Ref.) were treated with 'red light' at Finsen's instigation. As far as one could judge, the red light did not have the slightest effect on the intensity or duration of the exanthem, since no effect could be observed on either strong or weak exanthems. The initially relatively weak and pale exanthems spread undisturbed and later became very

1) F. THYMANN; Diphtheria and Scarlet Fever, etc. Hospital Year 1895. p. 270

intensive; the initially relatively severe exanthems did not fade any faster with this treatment, but the red light seemed to have a calming effect on several patients

Whether treatment with red light has a beneficial effect on the exanthema does not seem to me to be the most important issue, since this exanthema as such poses no danger to the patient; at most, such an effect would shorten the exfoliation and, consequently, the isolation. The main thing is whether this treatment has an influence on the course of the infection itself and on the other reactions of the organism; in particular, one must observe temperature, pulse, general condition, and cerebral functions (delirium, coma). If Thymann's impression that red light has a calming effect on patients was confirmed in repeated experiments, this is of far greater value than a beneficial effect on the exanthema, whether that a milder course of the disease or that the minimal exposure to light on the retina is the reason for the calming effect

Later, E. Schouli 1) tried the effect of red light on two cases of scarlatina, after having achieved excellent results in the treatment of smallpox using this method. Desquamation was not observed in any of the cases.

Festner (Riesa) informed me in a letter that he had used red light treatment on a case of scarlet fever. When the patient (a 14-year-old girl) was placed in red light, she had angina, 40.5° C, and lobster-red skin; 24 hours later, the fever had disappeared, her general condition was good, and the patient had an appetite; only her pulse remained at 110 to 106 for about four days.

1) E. Schouli (Tunis): Société de thérapeutique de Paris, October 11, 1899. Ref.: Zeitschr. f. dietetic and physical therapy, 3rd vol., p. 612

Th. Schüler in Berlin informs me that he has treated 26 cases of measles and 14 cases of scarlet fever with red light. In all cases, he had the impression that the treatment had a highly calming effect, even at a temperature of 40°C and above, as well as that the itching was less severe and that the exanthema and conjunctivitis disappeared more quickly.

Provincial doctor Backmann1 in Viborg (Finland) gave a brief report in his article "On Variola Vera and the Chemical Exanthema" that he had also found Finsen's method effective against other acute exanthematous infectious diseases, e.g., scarlet fever and morbilli. I wrote to Dr. Backmann for further clarification, and he sent me the following reply, for which I express my sincere thanks:

"Only 5 or 6 cases of scarlatina occurred at the hospital at that time (i.e., during the four years when Dr. Backmann was employed as a physician at the epidemic hospital in Kolikkomäki) and were treated using the same method. The exanthema was weaker and the desquamation followed more quickly, the fever disappeared within 48 hours, brain symptoms were hardly noticeable, and convalescence was faster. I could not perceive any influence of the method on the throat symptoms. After four years, the epidemic hospital was closed, but I always used Finsen's method in my private practice and derived much benefit from it, especially in the hundreds of morbilli cases I treated. The fever was always slight and of short duration, the catarrhal eye and lung affections were slight and

1) HERMAN BACKMANN: Finnish Medical Handling Manual, Vol. 50 No. 5, May 1898, p. 486.

No brain symptoms occurred. Therefore, I was particularly satisfied with the method, and the parents of the patients no less so; I intend to continually follow this good and practical method of treatment. As the provincial physician of a large district (6 municipalities with approximately 100,000 people), I have not been able to keep a journal or make notes on all the illnesses, but I can state with conviction and experience that Finsen's method is of great and real importance in the treatment of exanthematous illnesses, whose course becomes milder and more rapid.

. . ."

One can rightly object to Backmann's favorable impression of Finsen's method of treatment that it is entirely subjective and, as far as scarlatina is concerned, is certainly based on too little material

Chatinière, meanwhile, conducted some experiments with treating measles with red light during a widespread and typical measles epidemic, which fortunately supplemented Backmann's observations. Chatinière happened to conduct a kind of control experiment (Case No. 1), i.e., he let the patient lie alternately in red light and in full daylight, just as Finsen suggested in the passage cited above. The value of Chatinière's experiment is further increased by the fact that he did not expect to obtain favorable results from the outset, but tried this method of treatment "par simple curiosité." ChatiniÉre appears to have thoroughly excluded chemical light rays; however, he does not mention a spectroscopic examination. The first case history is so interesting that it deserves to be reported in extenso:

1) CHATINIÈRE: La Presse médicale, 10 September 1898, No. 75, p. 78

No. 1. "V. V., 8 years old, suddenly developed a headache and fever on the evening of July 19th. I was called; I diagnosed significant gastric disturbance, and since the child was predisposed to this, I prescribed a poultice. Two hours later, during which the child sweated profusely, an almost general eruption (head and body) of an undoubted nature appeared. There was photophobia, a cold, and a rough cough; the temperature was 39°C; all of this developed quite suddenly. I prescribed a sedative and a mustard poultice around the lower legs. The following morning at 9 o'clock the eruption was more pronounced, the eyes were red and swollen; there was loud wheezing, and the temperature had not fallen (39.3°C)."

I then advise covering the windows and doors with a red calico curtain, without any deeper conviction, merely out of curiosity. At noon, I go to the patient to see how my order has been carried out, and I note to my surprise that the eruption has completely disappeared; furthermore, the child, who is now afebrile, has become cheerful, even too noisy; he complains of not being able to see his toys. I then allow the parents, who cannot bear the patient's complaints, to remove the red curtains

Around 3 o'clock, the mother asks me to come quickly: the eruption has returned in its full extent; the fever and dullness have also returned. They ask if there are complications. I reassure the parents, have the red curtains hung up again, and give the order not to take them down again. After two hours, the eruption had disappeared, and the general condition was better. Shortly afterward, the cough and photophobia subsided. In short, within 48 hours the illness was over, and the child was convalescing; during the

desquamation, nothing was noticeable. After 8 days, the patient was given a bath and went out, and this case of measles, which initially looked so threatening, has on the whole progressed as calmly as possible from the moment the light was excluded

No. II was a 12-year-old brother of the previous child. He developed the usual initial symptoms. "Right at the beginning of the illness, the above-mentioned treatment was applied, and despite the intensity of the premonitory symptoms and the child's constitutional weakness, the measles ran its course in two days; the eruption lasted barely 12 hours. The child got up, had a bath, and went out on the sixth day without having experienced the slightest complication. The catarrh of the conjunctiva, nose, and larynx was minimal, without any medical treatment being employed."

No. III, a 5-year-old child, was ill for only four days; there was neither desquamation nor complication. The child got up, had a bath, and went out on the sixth day

No. IV, sister of the first two patients, was placed in the red light before any skin symptoms appeared. The entire course of the illness lasted barely three days. Whether an exanthema developed during the stay in the red light is not mentioned; the case history is very brief and summarized in a postscript.

Case histories Nos. II, III, and IV, taken individually, actually prove nothing other than that there are cases of measles that progress mildly and quickly, despite the presence of severe premonitory symptoms. More valuable is No. I, where the exclusion of the chemical light rays caused the severe symptoms (severe exanthema, Type 3913, dullness) to disappear within three hours

where these symptoms returned three hours after the red curtains had been removed, only to disappear again within two hours after the red curtains had been hung up again. If a sufficient number of such control experiments had produced the same result, they would have been definite proof of the excellent effect of treating measles with red light. This single experiment cannot, of course, be considered proof, but this and the three other cases of Chatiniere, in conjunction with the favorable impression made by Backmann and Schüler of the measles cases they treated, indicate enough that treatment with red light has a favorable influence on the course of this disease to give reason to continue the experiments

Attempts to treat other exanthematous infectious diseases, apart from — smallpox, with red light have not progressed further than that one must begin almost from scratch. This method of treatment must be attempted for these diseases as well, all the more so as it is completely harmless, not unpleasant for the patient, and easy to carry out even in private practice.

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Foreword.

Dr. G. J. Müller (Berlin) has kindly undertaken the major task of proofreading the translation, for which we hereby express our sincere thanks.

The translation of the book was done by Dr. Schramm

On the Application of Concentrated Chemical Light Rays in Medicine.

Continued reports by Niels R.

Finsen.

Since I published my treatise "On the Application of Concentrated Chemical Light Rays in Medicine" in December 1896, which was accompanied by a "Preliminary Report on the Application of the Method in Lupus Vulgaris," conditions have changed quite significantly. While at that time I had only used the method for one year and in two cases of lupus vulgaris, it has now been used for six years and in over 800 cases of lupus vulgaris, as well as in many other ailments. What was an interesting, promising experiment at the time has now proven to be significantly more, and the method has not only kept its promise but in many respects has far exceeded my expectations

The first and most important investigations on which the method is based are published in the above-mentioned treatise, but not my later investigations, which aimed to improve and expand the method.

In the various, quite numerous, communications I

reports on the treatment method that have so far come from the Light Institute (see list in "Reports from Finsen's Medical The Light Institute," I, p. 4) have essentially concerned the results of the therapy, followed simultaneously by reports on the essential changes and improvements in the treatment apparatus. On the other hand, almost nothing has been reported about why the changes were made; I intend to publish these underlying investigations here. At the same time, I want to provide a description of the method and its current status, both from a technical and therapeutic perspective

These investigations, most of which date back 4-5 years, are mainly of a physical nature; they have the quite natural characteristic of being conducted exclusively with a specific and practical goal in mind, as if by a non-physicist. Despite the resulting deficiencies, I still want to publish them, as there is a certain reason to do so. The method and my apparatus are already used in numerous foreign countries, and I therefore owe an explanation as to why the apparatus and the method are exactly as they are, why, for example, one needs glass lenses for sunlight and quartz lenses for electric light, why one should use clear distilled water for electric light-collecting apparatus and bluish-colored water for solar-collecting apparatus. These and other relationships

1) In carrying out these investigations, I received a great deal of help and support from my two assistants at the time, Doctors Valdemar Bie and Axel Reyn, to whom I hereby express my sincere thanks

seem to contradict each other and require a more detailed explanation. If I do not provide the explanations and the underlying experiments, I run the risk that the apparatus and technique will be changed in the wrong direction, to the detriment of the method.

First, I must make the remark that some of my investigations may be regarded as superfluous because the conditions are considered known. To this, I can only reply that, since it turned out that various physical data I had found on my subject (concerning the absorption of rays, etc.) did not agree with my experiences, and since the luminous intensity involved in my experiments far exceeded the luminous intensity usually used in experiments, I considered it most correct to reinvestigate almost all of the relevant questions

The types of these investigations naturally follow from the principles underlying the method, and these are, as is well known, 1. the use of the bactericidal and inflammatory ability of light, and 3. its ability to penetrate human tissue. 2. the

In order to be used in practice, the light must be highly concentrated and, at the same time, the large amount of heat must be eliminated to prevent the burns that the concentrated light would otherwise cause.

The questions that therefore demanded answers were the following: 1. Which rays in the spectrum are the most bactericidal? 2. To which rays is the inflammatory effect linked? 3. How

How can the annoying heat rays be eliminated most easily and best without simultaneously losing the useful, bactericidal and anti-inflammatory rays? 4. What is the situation regarding the penetration of light into tissue? In addition, other questions arose which also concerned light and which were partly dependent on the answers to the previous ones, namely: 1. What can be done to produce an artificial light that is rich in rays with the desired properties and poor in heat rays? 2. Which part of the electric arc light is the best, that which comes from the carbons or that which comes from the arc? 3. How does sunlight differ from electric light, and what significance does this difference have, partly for the construction of solar apparatus and partly for the treatment of patients?

This is followed by a series of investigations into how best to produce concentrated light so that as many of the beneficial properties as possible are retained and the detrimental heat rays are avoided as far as possible.

I will, if possible, treat each of the individual questions separately and either answer them or point out where an answer can be found.

1. Which rays in the spectrum are the most bactericidal?

I was already able to answer this in my above-mentioned first treatise (p. 6) that, as a result of numerous investigations, which I also found confirmed in my own experiments, the most refractable, the blue-violet rays, had — to be regarded as the most bactericidal, although some differences of opinion

arose regarding the most refractable of all, the ultraviolet rays. In more comprehensive investigations, which were later carried out at the Light Institute by Dr BIE[1]) on this extremely important point, and to which I refer, significantly more clarity has been disseminated regarding how extraordinarily large a part of the bactericidal effect of light is attributable to the most refractable rays and how small a part is attributable to the less refractable rays (the red and yellow). Dr. Bie's investigations were carried out with the help of collecting apparatus equipped with glass lenses, and his results are of the greatest importance for all rays that can pass through glass; but a large part of the ultraviolet rays is known to be absorbed by glass, whereas they diffuse rock crystal. It was now of great importance for the method to know how important these ultraviolet rays absorbed by glass are as bactericidal; this would determine whether rock crystal lenses should possibly be used for light-collecting — apparatuses, instead of the — glass lenses used until then.

I therefore conducted an experiment in this direction (on May 22, 1897, at 10:30 p.m.), which I report based on my book of experiments.

The light from an 80-ampere lamp was collected with the help of a small collecting apparatus consisting of a metal tube 6 cm long; one end of which was closed with a rock-crystal plate 6 cm in diameter, and the other end with a rock-crystal lens 5.5 cm in diameter and 6 cm focal length, with distilled water between them. With the help of this apparatus

1) Investigations into the bactericidal effect of the various parts of the spectrum. Reports from Finsen's Medical Light Institute, I, p. 40

The light was collected on a 6 mm diameter spot of a Prodigiosus plate culture, as we usually use it in the Light Institute, except that in this experiment I let the light fall directly onto the culture, i.e., onto the surface facing away from the glass. I made three experiments, each lasting 5 minutes. In the first experiment, a rock crystal plate was placed between the collecting apparatus and the culture; in the second experiment, a glass plate made of ordinary window glass; and in the third experiment, a somewhat thicker plate made of clear mirror glass. The examination, carried out the next day at 1:30 a.m., showed a weakening of the growth on all three spots. In the two spots where the light had passed through glass plates, the growth was approximately uniform, but very slightly weakened; much more pronounced, however, where the light had passed through the rock crystal plate (the three spots were side by side on the same plate culture). During the examination carried out the next day (the 24th) at 32:30 p.m., the illuminated area on the rock crystal plate was clearly visible; here the majority of the bacteria had been killed, and only a few isolated colonies had grown. On the two glass plates, however, growth was equally good on the illuminated and the unilluminated areas; the bacteria were pigmented everywhere, only somewhat darker in color on the illuminated than on the unilluminated part. This result, which I found confirmed in later experiments, shows an extraordinary preponderance of bactericidal ability in extreme ultraviolet rays. A necessary consequence of this experiment was the introduction of rock crystal lenses instead of glass in the treatment apparatus, and with this, as is understandable, an extraordinary amount was gained. How much was gained by this change

I can't give an exact figure, but you'll get an idea if I give you a few numbers. Dr. Bie found in his investigations that concentrated light from a 35-ampere lamp, concentrated through a glass collecting apparatus, killed a Prodigiosus culture after 35 minutes of exposure. Using a rock crystal collecting apparatus (with 7 cm lenses) and a lamp of the same size, I was able to kill a culture of the same bacteria in 2-3 seconds

In order to investigate how it behaved with sunlight, I later carried out some experiments, which were arranged according to exactly the same principle as the last-mentioned experiment with electric light. For this, I needed a collecting apparatus with a rock crystal lens 10 cm in diameter. The result here was quite different, as there was a very slight difference in the effects, regardless of whether the light had passed through rock crystal or through a thick plate of mirror glass. The sunlight that had only passed through rock crystal had the same effect on Prodigiosus in 4 minutes as light that had passed through a plate of glass had in 5 minutes.

From this, one gets a very good practical impression of how great the difference is between sunlight and strong electric arc light, with regard to the content of extreme ultraviolet rays retained by the glass. Sunlight contains relatively

1) This number could not be considered an absolute target for the difference in the performance of the apparatuses, since there are so many sources of error with regard to the cultures that were not taken into account in these experiments (see S. Bang's treatise: "On the Effects of Light on Microbes." Reports from Finsen's Medical Light Institute, II, p. 1); but it does give an approximately correct idea of the great difference between these two Arfen apparatuses

very few of these rays, due to their high degree of absorption by the atmosphere. From this it follows, for example, that sunlight on high mountains is much richer in these rays than in the lowlands (see Absalon Larsen's treatise: "On the Intensity of Sunlight." Reports from Finsen's Medical Light Institute, I, p. 99). In the strong, electric arc light, however, by far the largest part of the bactericidal effect is due to these ultraviolet rays.

Theoretically speaking, as a result of these experiments, one should use collecting apparatus with rock-crystal lenses for both sunlight and electric light, since such apparatus will definitely give better and stronger light. But in practice, the ratio is different

I will first discuss how it behaves with sunlight. Since the rays are parallel here, the intensity of the light, all other things being equal, depends on the size of the lens area. This ratio is very favorable with regard to glass; since one can easily obtain glass lenses as large as one needs them; but unfavorable with regard to rock crystal lenses, since the limits for the size of lenses of this type of stone are very narrow. The largest rock crystal lens that I have seen and could obtain had a diameter of 11.5 cm; but such lenses are very rare and very expensive; whereas one can fairly easily obtain rock crystal lenses with a diameter of 7 to 8 cm, although these are, of course, also expensive.

From my experiment with bacteria described above, it emerged that one can roughly determine the ratio between a rock crystal lens and a glass lens of the same diameter, the same

1) While rock crystal lenses with a diameter of 10-11 cm cost 150-200 kr., those with a diameter of 7-8 cm cost approximately 30 kr. each.

focal length and the same thickness, could be specified as 5 to 4 when it came to utilizing the bactericidal power of sunlight; in other words, only a very slight increase in diameter is needed to make a glass lens equivalent to a rock crystal lens. For example, a glass lens with a diameter of 11 cm is equivalent to a rock crystal lens with a diameter of 10 cm. But if one further considers how disproportionately the area increases in relation to the diameter, so that, for example, a lens with a diameter of 20 cm has an area four times as large as a lens with a diameter of 10 cm, one will understand how disadvantageous the use of rock crystal lenses would be for sunlight.

It is different with electric light Firstly, the usefulness of rock crystal, as I have shown, is extraordinarily greater here than with glass, and secondly, the size of the lens area plays a significantly smaller role because the rays are diverging. If a lens with a small area is placed close to the light, it can, as is well known, collect an equal or even greater amount of light than a lens with a much larger area placed at a certain distance from the light. Of course, the size of the lens is not absolutely irrelevant, since placing it too close to the glowing coal tips entails certain practical disadvantages (they crack easily and are quickly dusted by the carbon particles constantly falling during the combustion of the coal). However, at a reasonably large distance from the arc (12-15 cm), these disadvantages are not very great, or at least small compared to all the advantages of using rock crystal. Even the high price of these lenses is of secondary importance if one considers the high cost of these lenses.

considering the tremendous difference that exists between glass and rock crystal compared to this light. 1)

2. To which rays is the inflammatory effect linked?

I can limit myself to answering this question very briefly by referring to my treatise: "New Investigations on the Effect of Light on the Skin" (Reports from Finsen's Medical Light Institute I, p. 8), where I made it the subject of detailed investigations. The answer is that it is exactly the same rays that have a bactericidal effect and that there is the same, or approximately the same, difference in the effects on the skin as on bacteria with electric light that has passed through glass or that which has passed through rock crystal. 2) As a consequence, everything applies

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1) This transition to the use of rock crystal lenses with electric light was, incidentally, actually a return, since I had already needed a rock crystal collecting apparatus for lupus treatment in the winter of 1895-1896. The development was as follows: I began (in November 1895) with a glass lens, but it soon became clear to me that rock crystal was — theoretically preferable. I therefore obtained rock crystal lenses that same winter. But since they turned out to be extraordinarily expensive and could only be obtained in very small diameters, I returned to glass lenses. This return to glass was certainly quite correct at the time; partly because I only had a weak arc lamp with relatively few ultraviolet rays at my disposal at the time, and partly because I had not yet arrived at the use of the double lens system (with spaces between parallel rays), which completely changes the situation and, so to speak, eliminates the advantage of the large-diameter lenses

2) Whether they are exactly the same rays cannot, of course, be said with absolute certainty; but as far as one can judge from the methods of investigation currently available, they are the same.

What I said in the previous section also applies in this section. In order to produce the most powerful possible effects of light, it is most appropriate to use rock crystal lenses in electric light and glass lenses in sunlight.

3. How can one most easily and best eliminate the irritating heat rays without simultaneously losing the useful, bactericidal and anti-inflammatory rays?

Completely eliminating the heat of light is a physical impossibility, since all rays of light have the property of generating heat, only to varying degrees. Therefore, in the question posed, I spoke only of the "generating" heat, and what I understand by this expression I can state quite definitely in numbers. In numerous measurements of the heat of the light cone, which patients could tolerate without feeling pain, I found that 45–55°C can be set as the average for what is tolerable.

The task now was to construct apparatus that could produce a light cone with the highest chemical luminous power without exceeding this temperature at the focal point. The work involved was partly of a common nature, partly different for electric light and sunlight, so that I must partly treat each separately

I need hardly note that, hand in hand with these various investigations and as a result of them, the construction and reconstruction of collecting apparatuses were continually being made, so that various intermediate stages lie between the apparatuses which

we need now, and those discussed in my above-mentioned book of 1896. It is not worth the effort to dwell on most of these transitional forms; I will only discuss the most essential ones below.

Common to both types of light were the investigations into the ability of water and various solutions to absorb heat rays and chemical rays. I have already discussed some of the investigations in this direction in my treatise of 1896; but the most essential investigations were carried out later

The questions that needed to be answered, with regard to the clear, uncolored water, were the following: What is the absorption by the water with regard to a) heat rays and b) chemical rays? c) What is the significance of the thickness of the water layer? and d) What is the significance of the temperature of the water? This was followed by e) investigations into the light absorption ratio of the various solutions in order to find the solution best suited to the collecting apparatus, i.e., the solution that absorbed the largest part of the heat rays and the smallest part of the chemical rays.

a) The absorption of heat rays by the water.

For these and the following experiments on absorption, I used the light from a 35-amp arc lamp, which was concentrated with the help of one of my electric light-collecting apparatuses as described in l.c., p. 19. To determine the temperature, I used a mercury thermometer whose bulb was blackened with soot

was. In all experiments, the thermometer was held at the same point on the light cone, at its focal point.

First, I measured the temperature without filling the apparatus with water; it showed 325° C. (Mean of three measurements: 290°, 360°, and 324°). I then filled the apparatus's container with water, and the thermometer now showed 111°. (Mean of 6 measurements, which varied between 89 and 123°.) The thickness of the water layer passed through by the light was 13 cm.

The rather large difference in temperatures in the experiments, which were carried out with quite large intervals, is to be attributed to the lamp, whose light is rarely uniform in the same place for any length of time; for even if the current and voltage are kept completely unchanged, the shape of the crater, for example, can produce a large difference in the luminous intensity. For my purposes, these results were nevertheless subtle enough

One can see that the layer of water has reduced the temperature of the light by more than 200. Since we now know that water absorbs only a very small amount of the visible rays of light, this loss of heat must be due mainly to the absorption of the invisible, ultra-red rays of light.

To find out whether all of the ultra-red rays or how large a portion were absorbed by the layer of water, I placed a 1-cm-thick light filter filled with an opaque solution of iodine in carbon disulfide between the apparatus and the thermometer (this solution absorbs all light rays except the ultra-red ones). The thermometer now showed 26° (room temperature 20°). From this one can see that the layer of water has almost completely eliminated the ultra-red rays. If

I placed the same filter in front of the collecting apparatus to conduct a control experiment and simultaneously emptied the water container, the temperature at the invisible focal point rose to 172°.

b) The absorption of chemical rays by water.

is the most penetrative, or one of the most penetrative, liquids for the chemical rays of light, and experiments can show that the loss of the chemical effect of light through passing through a layer of water is actually quite negligible. When it comes to glass apparatus, it can even be demonstrated that the water is beneficial; if one measures the chemical effect of the light cone after it has passed through an empty glass light filter, and then measures the effect after the light filter is filled with water, one will see that the effect is strongest in the latter case; this is explained by the fact that the reflection from the glass sides is less when there is water in the filter than when it is empty I carried out my experiments by allowing the light cone to act on silver chloride paper (Aristo paper). The paper was placed on the same spot on the light cone in all experiments, and the experimental time was the same for all comparative experiments. By then comparing the colors on the areas blackened by the light, I was able to obtain a quick and, for my purposes, sufficiently reliable idea of the absorption of chemical rays.
1)

1) As far as I —remember (I have not noted anything on this in my experiment book), all my experiments were carried out with distilled water,

c) The Significance of the Thickness of the Absorbing Water Layer

In practical terms, it is of great importance whether the collecting apparatus should be constructed with a thick layer of water or whether a thin layer can be sufficient. For apparatus for electric light, this is relatively less important, since these are fixed and supported by strong iron arms. For solar apparatus, however, this question is of great importance. If the water layer is large, the apparatus becomes very heavy and unwieldy. As an example, I will cite the solar apparatus described in my above-mentioned book on page 17; it has a water layer 40 cm thick and contains 10 liters of water. Because of its weight, it was difficult to transport, its use was cumbersome, and it is therefore no longer used

I carried out the relevant experiments with the same lamp, the same apparatus, and in the same manner as described on page 12, gradually filling light filters of different thicknesses with water and placing them between the apparatus and the filter. Since I did not have filters of all thicknesses, I sometimes placed several filters one behind the other, which does not correspond absolutely to the same thickness of a single filter[1]), but as the figures show, this plays no essential role in such crude experiments as mine. —

which we always use with apparatus and light filters. There is a difference between ordinary and distilled water with regard to the absorption of the extreme ultraviolet rays (see Absalon Larsen's treatise, Mitteilungen II, p. 110).

1) The more glass surfaces the light passes through, the greater the loss of light due to reflection

The results of these experiments are recorded in the table below, in which I list the thickness of the water layer, the number of filters, and the temperature.

Thickness of the water layer	Number of filters	Temp. at focus.
0	0	325° C.
1 cm	1	180° ,,
2.5 cm	1	126° ,,
3.5 ,,	2	114°
13 ,,	no filter but water in the same apparatus	111° ,,
26 ,,	Water in the apparatus + in the filter	107° ,,

One can see from this table how important even a thin layer of water is, and what comparatively little advantage one gains by making the water layer very thick. Consequently, one should not use a thick layer of water, since this has the inconvenience of making the apparatus heavy and unwieldy, whereas it would be more convenient to use a thick layer of water where these considerations do not need to be taken into account. With solar apparatus, which have a large diameter and must be frequently moved from one place to another, this plays a major role, as stated above; therefore, in the latest designs of these apparatus, I use a water layer only 4-5 cm thick. With electric light apparatus, the relationship is reversed; the lenses have a small diameter, and the apparatus is firmly attached, therefore

one can use a thick layer of water here without any inconvenience; therefore, for the latest designs, I need a water layer of 35 cm.

d) The importance of the temperature of the absorbing water layer

assume that the temperature of the water layer must be important when it comes to the absorption of heat rays, in such a way that cold water absorbs more than this seems to be the general opinion, since almost all medical investigators warm absorbed. One should who have worked with light without heat emphasized allowing the light to pass through a layer of water that was constantly kept cold. A decision on this question was all the more necessary for me because the water in the light-collecting apparatus became very warm after a few hours, almost reaching boiling point, and cooling the water by constantly flowing cold water through it in one way or another was a very complicated process, which I only wanted to resort to if it was absolutely necessary

My experiments on this topic were carried out with the same lamp, the same apparatus, and in the same manner as in the above-mentioned investigation. There was no water in the apparatus itself, but a light filter 1 cm thick was placed between the apparatus and the thermometer. This light filter was gradually filled with water at 5°, 45°, and 73°. The corresponding temperatures, measured at the focal point, are shown in the table below. I cannot remember how many experiments of this type I conducted; in my book, only the following are noted:

Filter of 1 cm	Water 50	T. 174°
,, ,, ,, ,,	,, 45°	,, 198°
,, ,, ,, ,,	,, 73°	,, 180°

After these measurements, whose variations can be considered within the normal limits of error (see p. 13), I had seen in any case that there was no significant difference in the absorption capacity of the water, regardless of whether it was cold or warm, and I therefore considered it unnecessary to make any arrangements to cool the water in the collecting apparatus. If I nevertheless later (see p. 38) switched to cooling the water in the apparatus, there were other reasons for this

Before I conclude my remarks on water, I would like to point out that it is absolutely necessary to use freshly distilled water for both solar apparatus and electrical apparatus. Apart from the possible absorption ratio (see Absalon Larsen's article cited above, p. 110), there are two practical considerations that make the use of ordinary water disadvantageous. First, as the water heats up, numerous air bubbles are deposited on the lenses, causing them to lose an extraordinary amount of luminous intensity. Second, ordinary water gradually deposits calcium salts. We have also tried using boiled water, but have not been able to obtain sufficient clarity so far.

e) Investigations into the absorption of heat and chemical rays by various solutions.

As discussed in my above-mentioned treatise (pp. 14-15), I used both

For both electrical and sunlight, a solution of methylene blue removes even more heat rays from light than water alone is capable of. In order to find out which solution is best able to absorb heat rays and at the same time allow chemical rays to pass through, I undertook a series of experiments.

First, I spectroscopically examined all the clearly soluble blue dyes that I was able to create; I found that methylene blue, alkali blue, and an ammoniacal solution of copper sulfate best met our requirements. The first two showed an almost completely uniform absorption spectrum when examined spectroscopically, but the methylene blue spectrum was apparently the most favorable, and with this substance and the ammoniacal solution of copper sulfate, I therefore carried out a series of comparative experiments to directly determine, with the aid of a thermometer and photographic paper, their ability to retain heat rays and allow chemical rays to pass through

Since these are the same dyes that I discussed in my above-cited treatise, and since later, more detailed investigations have shown that the assumption I made at that time was not entirely correct, I will cite what I said then and correct the circumstances at the same time. It says in 1. c. p. 15: "Since the ammoniacal solution of sulfuric acid of copper oxide quickly stains upon contact with the metal sides of the apparatus and its use is otherwise less pleasant, I have now switched to methylene blue solution. The sulfuric acid solution of copper, if sufficiently strong, does not include 2*

completely extinguishes the red rays, but a strong methylene blue solution does not. On the other hand, upon spectroscopic examination of a weak, apparently equally intense solution of the two colors, one will see that the methylene blue solution absorbs more red rays than the copper sulfate solution; and since, as a rule, one only has use for a partial exclusion of the red rays, the methylene blue solution is preferable for this reason as well.

The experiments I wish to discuss here were carried out with the same lamp and the same collecting apparatus as in the above-mentioned experiments on the absorption of water, and with the same 1 cm thick light filter. The temperatures mentioned here could therefore easily be compared with the temperature (180°) discussed above for a layer of water 1 cm thick; such a comparison provides a numerical impression of the filtration of light through blue-colored water

For the experiments, I prepared two deep blue, apparently uniformly colored solutions of methylene blue and copper sulfide with ammonia. The light filters with these solutions were then placed alternately in front of the light cone, and the temperatures at the focus were measured.

The result of the experiments was that I found a mean value of 61° for the copper solution and 116° for methylene blue (for clear water, the temperature was, as mentioned, 180° under the same conditions). By testing the effects on photographic silver chloride paper, it was shown that the copper solution allowed more chemical rays to pass through than the methylene blue solution.

Water was then added to the collecting apparatus.

(a 13 cm water layer). The temperature was 111°C, as mentioned above; when the copper filter was placed in front, the temperature at the focus fell to 34°C; when the methylene blue filter was placed in front, it fell to 57°C.

The solutions used here were, as mentioned, quite dark; in experiments with a weaker solution (the same solution half diluted with water) and with water in the collecting apparatus, the temperature at the focus was 45°C for the copper solution and 580°C for the methylene blue solution.1) This last experiment, however, demonstrates the correctness of what I said at the time about the difference between a weak and a strong methylene blue solution compared with the copper solution. The main result, however, remains that, both with regard to heat removal and the lower absorption of chemical rays, the ammoniacal solution of sulfuric acid of copper oxide is absolutely preferable

I also conducted comparative experiments, arranged in the same way as these last, between an ammoniacal copper sulfate solution and various solutions that are said to have a particularly high absorption capacity for heat rays, namely: solutions of alum, ferric sulphate, iron chloride, and others. But the result was that the copper solution was far preferable to the others. For these reasons, we now always use copper solutions for collecting apparatus when more heat is to be absorbed.

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1) Since it is surprising that this number is approximately the same as for the stronger methylene blue solution, I will cite the results of the individual measurements. Both numbers were the average of three measurements; for the strong solution, the temperatures were 570, 540, and 610; for the weak solution, 690, 480, and 560

should be greater than water alone can achieve. We attempt to reduce the disadvantages mentioned in the use of copper solutions (rapid decomposition, etc.) by coating the metal that comes into contact with the solution with asphalt varnish.

We constantly need copper solution for sunlight-collecting apparatus, as it offers greater advantages. We also needed it for electric light-collecting apparatus for a while, as long as we still used glass lenses; but since rock-crystal lenses were introduced, the copper solution could no longer be used, as it absorbs chemical rays to an even greater degree than glass in the liquid thicknesses under discussion here.

4. The penetration of light into tissues (compressed glass).

To enable the chemical rays to penetrate the tissue as deeply as possible, we always use a pressure glass, which pushes the blood away from the area to be treated, which, as I have demonstrated (1. c., pp. 31-33), is of great importance. This is, of course, most important when treating deeply infiltrated areas. On the other hand, we have learned that with very superficial affections

Fig. 1. Half natural size.

the goal can also be achieved without a pressure glass, e.g., in some cases of superficial lupus of the

canthus and the upper eyelid, where it was not possible to use a pressure glass because of the condition of the eye

It is clear that the pressure glasses must be shaped differently depending on the places where they are to be applied. In addition to the shapes discussed earlier (see 1. c. p. 33), I will also mention a pressure glass with a concave plate (for treating the vertex) and a special shape, a small oval pressure glass with a handle (see Figure 1), which we use for treating the canthus of the eyes and other places where it is difficult to use the ordinary pressure glass.

Of greater importance is a change that I introduced (1897) in the pressure glasses and which I will discuss in more detail, since it actually represents a great improvement in the method from a practical point of view. This change consists in the use of a hollow, water-filled pressure glass through which cold water flows continuously by means of a supply and discharge tube

In the constant endeavor to eliminate the uncomfortable warmth of light, I had, as can be seen from the foregoing, essentially attempted to approach this goal with the help of media that absorb heat rays. I had, in fact, experienced that the sensation of warmth diminished as soon as the pressure glass was pressed against the skin; but one day, when I experimented with the light of a collecting apparatus on my arm and felt a strong burning sensation, even though the light had passed through a thick layer of water, we tried sprinkling water over the skin, and the sensation of warmth disappeared completely. The same thing happened when a pressure glass was placed on the skin and surrounded by water

trickled over. Further experiments showed that even extremely warm light, which immediately caused the most terrible pain on the arm, could be tolerated as soon as the skin was covered with a pressure glass over which water was trickled. Since constant trickling is, however, not easy to carry out in practice in the treatment of patients, I tried to see whether a hollow pressure glass filled with cold water could be sufficient. The experiment showed, however, that the advantages brought about by the constant changing of the water were so disproportionately great that I decided to introduce the hollow pressure glasses with flow mentioned above Through this change, the pressure glasses, or as one should rather call them, pressure apparatus, have been given two functions: partly to press away the blood, and partly to have a cooling effect on the skin (through conduction). These two functions are so important and essential, and of such great significance, that the third effect they exert, namely to absorb heat rays, is completely disregarded from a practical point of view.

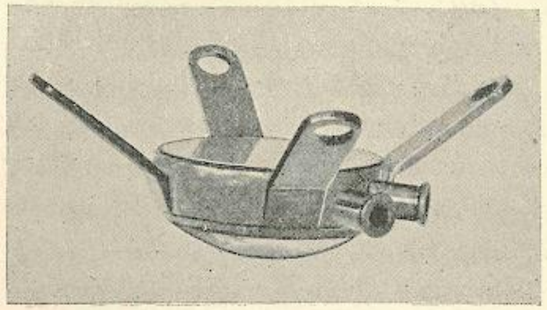

Fig. 2. 2/3 natural size.

1) While, as I have previously demonstrated, it is quite unimportant whether the water in the containers of the collecting apparatus contains warm or cold water, since the water's absorption capacity for heat rays is approximately the same in both cases, the situation is quite different with the water in pressure glasses, which is supposed to have a cooling effect through conduction; in this case, the colder it is, it naturally cools the skin more.

can be left. As soon as there were no water in the collecting apparatus, they would be of great importance, since even a thin layer of water (see my table on p. 16) is of extraordinary use. However, since the provision of a layer of water in the collecting apparatus does not pose a disadvantage, but on the contrary brings a great advantage, since the water layer can be made very thick in one case (electric light) and blue in the other (sunlight), this arrangement is naturally preferable. From the table above, one can also see that the heat radiation absorption of the pressure apparatus is practically irrelevant, since almost all heat rays that can be absorbed by water are already absorbed in the collecting apparatus

The great practical importance of the introduction of these pressure apparatuses with water trickling through them is perhaps best illustrated by the following experiment. I attached a hollow pressure apparatus to my arm, through which water (12°C) flowed, and then exposed my arm to the light cone of a large sun-collecting apparatus (a glass lens of approximately 30 cm diameter filled with clear water). I then tested how close I could bring my arm to the focal point without feeling pain. The distance from the lens was then measured, and a mercury thermometer, the bulb of which was blackened with pine soot, was placed at exactly the same spot. The temperature showed a height of 220-230°C; a small piece of wood, which was placed in the same place—where my arm had been—immediately emitted columns of smoke and glowed. If one considers that the temperature of the light cone, which had generally been achieved with the pressure apparatuses used up to that point—

was 45-55° C., then one will understand how important this improvement in pressure apparatus was, and how much stronger light we were able to use in treatment after its introduction. While previously we were not allowed to use lamps stronger than 35-50 amps, we could now use those of 60-80 amps

The reason that the skin can be exposed to radiant heat without pain or harm, which under other circumstances would carbonize it, is, of course, that cooling, the conduction of heat, occurs more quickly than the warming of the skin through absorption of the rays. A material that conducts heat well is therefore preferable, and since rock crystal, like all other precious stones, is a significantly better conductor of heat than glass, its use in pressure apparatus is preferable to glass for theoretical reasons. I will add that this advantage in conductivity is large enough to also have practical significance. Since, as discussed previously (p. 6), we introduced rock crystal lenses in collecting apparatus for electric light, we naturally did the same for pressure apparatus; thus, one sees that there are two reasons for using rock crystal; and one now understands the apparent lack of consistency in using collecting lenses made of glass for sun treatment but pressure apparatus made of rock crystal

Collecting Apparatus for Sunlight.

Their form has changed not so little over time as a result of the previously described investigations into the absorption of light. From the form of collecting apparatus which we described in 1. c. p. 17

to the form which we currently use, and which has undergone no essential changes in the last three years, there have been numerous transitional stages. Although it might seem unnecessary to discuss these transitional forms, I will nevertheless do so in the case of some of them in order to have the opportunity to explain why we were not satisfied with these forms; this is the best way to prevent others from taking the same path again in the belief that they are making improvements

The solar apparatus, described in 1. c. p. 17, but which was by no means the first form, consisted of two solid glass lenses, one 30 cm in diameter and the other 18 cm; between these two was a layer of water 35 cm thick. The apparatus contained 10 liters of water, was difficult to transport and set up, and so difficult to move from one place to another that we often preferred to change the patient's position according to the movements of the sun.

In the investigations discussed earlier (p. 15) on the importance of the thickness of the water layer, it had since become apparent that such a thick water layer was of relatively little advantage. I therefore constructed the following solar apparatuses with a much thinner water layer, which made them considerably more manageable

Because the large, solid glass lenses were relatively expensive, I tried to get hold of some hollow glass lenses; but since I wasn't lucky enough to find a glassworks that could or would make them, I tried using large watch glasses cemented into a metal ring. These lenses were considerably cheaper, but only became really usable after

were about 10 times cheaper than the others), I went back to using solid glass lenses, but in such a way that only one side of the apparatus consisted of a lens (flat-convex, with the flat side facing the water), while the other consisted of a flat mirror glass plate

It soon became apparent that, for reasons I will return to later, it was impractical to use very large lenses (40 cm in diameter). The size 20-30 cm in diameter proved to be the most useful, and a lens of this size was not difficult to obtain, but only one with a fairly strong curvature. The resulting consequence was the rather short focal length of the lens (30-40 cm), which is why the collecting apparatus always had to be placed very close to the patient. Since this proved very uncomfortable, I proceeded to make one side of the lens flat by using mirror glass instead of the one curved lens; this doubled the focal length and made the use of the apparatus much more convenient. This is the simple reason why the lens in solar apparatus is always flat-convex, a relationship that constantly gives rise to many questions

In the meantime, I have not yet succeeded in obtaining glasses as good as I could wish for. Due to the manufacturing method—as far as I know, a large sphere is first blown, from which the lenses are cut out as segments—they are never completely accurate and never collect the light as well as ground, solid lenses; the cross-section of the light cone at the focal point is often irregular (angular, oval, etc.). Since I thought that perhaps more was actually lost through this irregularity than what was gained in the other direction, namely through the cheapness of the lenses (they

I obtained curved glasses, specially made for this use. However, it was only successful after numerous unsuccessful attempts, since some technical difficulties are associated with making them of significant size and exactly spherical

This had the advantage that the light was nicely collected, so that the light cone was regular and round at the focal point. A further advantage was that the blue-colored water layer was the same thickness everywhere. If, on the other hand, the lens is made of curved glass, the water layer is naturally thickest in the middle, which is disadvantageous because the central rays (which are considered the most valuable because they can be collected best and are refracted least) have to pass through the thickest water layer and are thus absorbed more strongly than the peripheral rays. But when I conducted comparative experiments with two apparatuses of the same diameter and under exactly the same conditions, it turned out that the apparatus with curved glass, despite its lesser ability to collect light, killed bacteria more quickly than the apparatus with a solid lens. This difference must undoubtedly be due to the greater absorption of chemical rays by the thicker glass. Here, therefore, the cheapest was also the best

In order to possibly eliminate the disadvantage of the greater thickness of the blue water layer in the center than in the periphery, which was particularly important with large apparatuses when the liquid was to be relatively dark in strong sunlight, I conducted some experiments.

I constructed some apparatuses whose lens was filled with clear water; either in front of or behind it, I placed a light filter with flat walls, and

filled with the blue liquid. In other apparatuses, I used blue glass plates instead of filters, so that one could use one in weak sunlight and two or more in stronger sunlight. The apparatuses with the light filters were soon abandoned because they proved to be too heavy and unwieldy, as were the apparatuses with the blue glass plates because it proved impossible to obtain glass of a matching color. A comparison with colored solutions (copper solutions) showed that blue glass allowed more heat rays and fewer chemical rays to penetrate than the blue solution. I then tried covering the flat surface with transparent, blue-colored gelatin, but this also proved impractical. All these and other methods of achieving uniform absorption of heat rays over the entire area of the lens later proved to be quite superfluous, since it gradually became clear to me that the use of very large lenses offered no advantage

Experiments have shown that when the liquid was made very deep blue—which was necessary with large lenses because they gave off so much heat—they absorbed so many chemical rays that the advantage expected from the large lens area was actually lost, so that these large lenses often provided even less benefit than lenses of significantly smaller area, filled with a lighter solution. Experience has shown that, for this reason, at least in our latitude, it is impractical to use lenses larger than about 30 cm in diameter.

One might perhaps ask here whether it would not be better to use large lenses in order to enlarge the treatment spot in this way; this would at the same time

achieve the treatment of a larger area in a timely manner. However, this could not be done because the light outside the focal point of the lens collects too unfavorably to be of any use. If one wants to use the light within the focal point (between the lens and the focal point), one gets a disproportionately strong amount of light in the periphery of the spots and very little light in the center; if, on the other hand, one wants to use the light cone outside the focal point, one gets the exact opposite: overly strong and warm light in the center and very weak light in the periphery. This relationship can be easily and clearly confirmed by applying photographic silver chloride paper to the various points of the light cone and examining the shape of the blackened figure

I must add that I have conducted experiments collecting sunlight with a parabolic mirror made of silver instead of lenses; but I quickly gave up because the collected light was extraordinarily warm and, at the same time, relatively poorer in chemical rays. I have already mentioned (p. 8) that I also conducted comparative experiments between solar apparatuses with glass lenses and those with quartz lenses.

The result of these investigations and experiments

1) I must note that the problem could be partially solved by manufacturing solar apparatuses with very slightly curved lenses; such a lens would provide a good focal point over a larger area. However, for the first, I have not yet succeeded in obtaining large, slightly curved glasses, and for the second, the very long focal length that such a lens would have to have would entail frequent relocation of the collecting apparatus, so that the advantage of such apparatuses would possibly be very small or even zero in practice. Experiments in this regard would be advisable if such lenses could be obtained

with the collecting apparatus mentioned here and other forms, I have provisionally settled on a collecting apparatus of the form I will now describe and which can be seen in the accompanying picture.

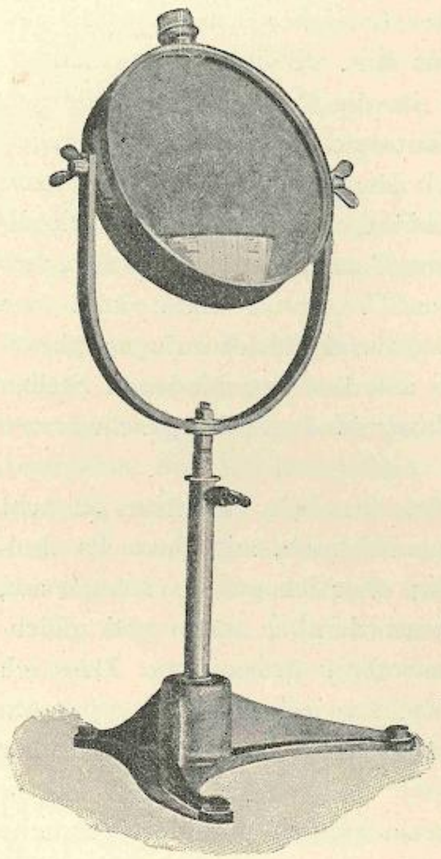

Fig. 3. 1/5 natural size.

The apparatus consists of a tripod and a lens. The tripod, which is intended to be placed on a table, carries a fork at the top, which in turn carries the collecting lens. This fork can be rotated, raised, and lowered around both a vertical and a horizontal axis, depending on whether the sun is high or low in the sky

We have convex lenses of various diameters and focal lengths; but the dimensions that I consider most favorable for Danish latitude are of approximately 25 cm, a focal length of approximately 70 cm, and a distance between the two lenses a diameter —, forming the lens of 4-5 cm at the periphery. Whether one uses biconvex or flat-convex lenses is irrelevant; one must only ensure that the lenses are as thin as can be combined with sufficient strength.

These convex lenses are filled with distilled water, which is colored blue with an ammoniacal solution of copper sulfate, which is of course always completely clear and transparent. The strength of the solution cannot be determined precisely, as it must vary depending on the intensity of the sunlight. A solution of medium color can be considered to be 0.3 grams of cupric sulfur dissolved in 900 grams of distilled water, to which 100 grams of ammonia water (4%) has been added. If one wishes to strengthen or dilute the solution, this can be done by adding more or less copper sulfate; the amount of ammonia, however, must always be the same. A solution stronger than three times as strong as the one mentioned above should not be used, as otherwise too many chemical rays will be absorbed

despite all this, the light heats too much, which hardly ever — If, happens with a lens with a diameter of 25 cm, then instead of making the liquid bluer, one should cover a smaller or larger part of the lens segment.

I do not need to specify any limit for the descending strength of the solution, since, with regard to chemical rays, it is obviously most advantageous to have a liquid that is as little colored as possible. If the sunlight on this or that occasion heats so little that the liquid can be made completely clear, it only means that it is better to use a lens with a larger diameter and a blue-colored liquid.

In addition to these apparatuses, sun treatment also requires small tables that are firmly positioned and have a top that projects freely to the north (since the table legs make it difficult for the patient to approach).

must be, as well as with a water pipe for the pressure glasses. Since it may be of interest to those who wish to use this treatment, I will describe the sun treatment facility at this institute.

In the courtyard where the sun treatment takes place, two rows of small tables (28 in total) are set up. The tabletops, which are either round, with a half-meter diameter, or square, are supported by a stake driven into the ground. The distance between the tables is 2/3 meters. Along the rows of tables, resting in the air on 21-meter-high supports, is a water pipe. Just above each table, this pipe gives off a drainpipe equipped with a tap, from which a gutta-percha hose leads to the pressure apparatus. From this, another hose leads to a drainpipe installed beneath the table, which flows into a drain channel below on the ground This water pipe, as well as the one for treatment with electric light, caused me some difficulties at first because the water pressure was too strong. But now that I have arranged it so that the water pipe is not in direct connection with the city's water supply, but comes from a container located at a height of about 3 meters (on the floor of the treatment room), it works very well and easily. The container has an inlet pipe equipped with a float valve, so that the container is always filled with water to a certain height. In the bottom of the container are drain pipes that supply both the sun treatment water pipe and the electric light treatment. For safety reasons, the container is equipped with a drain near its upper edge.

Fig. 4. Treatment with Sunlight

tube, in case the faucet or floats fail.

Collecting apparatus for electric light.

These apparatuses, like the sun-collecting apparatuses, have undergone some changes over time, but not as many as those. The most essential and significant change is that, after an experiment (mentioned on p. 5) in May 1897, I exclusively used rock crystal instead of glass lenses. But since, before this experiment, I had used glass collecting apparatuses of a somewhat different construction than those described in 1. c., p. 19, for the treatment of lupus patients for some time, and since I have not described them in any Danish treatise until now, I consider it proper to give a brief description of them

As can be seen from the accompanying drawing (Fig. 5), which shows a cross-section of such an apparatus, the difference between this and the one mentioned above is that there are two flat-convex lenses instead of three at the point facing the light, and that the water layer is bordered by two likewise flat-convex lenses. The lenses are of a significantly larger diameter (25 cm instead of 17), and the water container contains approximately 10 liters of water. While the water container in the first apparatus was filled with blue solution, in the last it was filled with clear water, while the blue solution was placed in a light filter c: a flat glass container placed in front of the lowest lens. Several such light filters with different strengths of solution were present, so that by quickly and easily replacing them, the light could be made more or less warm according to the patient's wishes.

However, we had not had these relatively good apparatuses for long before the introduction of apparatuses using rock crystal became necessary. As can be seen from the above investigations, only rock crystal and only clear water could be used with these apparatuses. The change which occurred in the

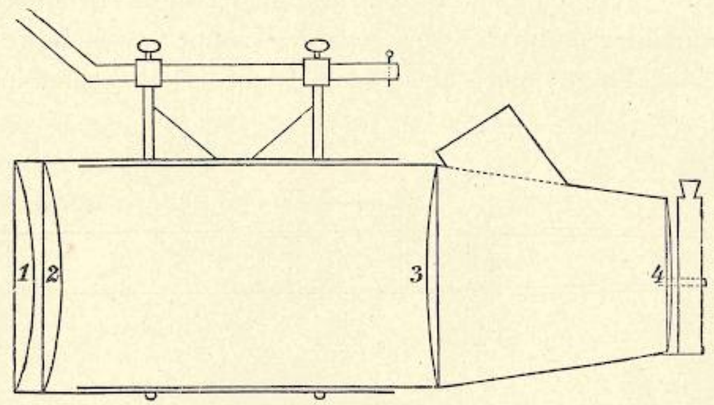

Fig. 5. 1/10 natural size

The main difference in the form now described was that the light filter was omitted, and the metal tube became significantly thinner; instead of 25 cm in diameter, it was now only 7-8 cm, because rock crystal lenses of larger diameters are difficult to obtain. This change makes the collecting apparatus currently in use (Fig. 6) resemble telescopes, a comparison that is also natural because the two metal tubes can be pulled apart and pushed into each other, just like in a telescope. While the position of the lenses relative to each other is entirely similar to the described apparatus with glass lenses, the long, thin shape of the apparatus has caused some differences. On the one hand, I was able to make the water layer very thick without any problems

(approx. 35 cm), otherwise special measures must be taken to center the apparatus in relation to the light point.

Since it cannot be avoided that the light point, even if the lamp burns with a so-called fixed focal point, changes its position slightly - either due to irregular burning of the carbons or due to the lamp moving slightly - the result will be that the light is somewhat crooked in the

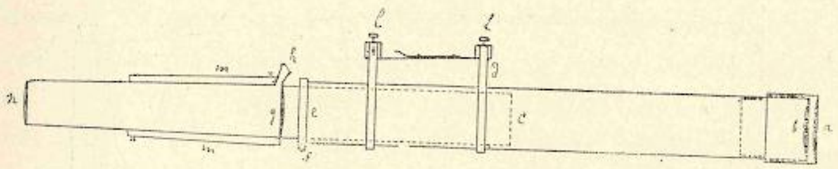

Fig. 6. 1/10 natural size

on the tube, and since the path through it is so long and the tube so thin, there is a great loss in the lowest part of the tube, falls where the light comes out. To remedy this, it is first necessary, with the help of shrouds and a so-called "wire fence stretcher," to fix the lamp as well as possible in the center of the ring that supports the four collecting apparatuses (see illustration p. 39); but then also to suspend the apparatuses so that they can be centered. This is done with the help of three screws located at the lowest suspension point of the apparatuses, while the center around which they rotate lies at the uppermost suspension point.

In the latest rock crystal apparatuses, the uppermost half of the tube, which contains water, is provided with a double wall through which cold water can be passed, and

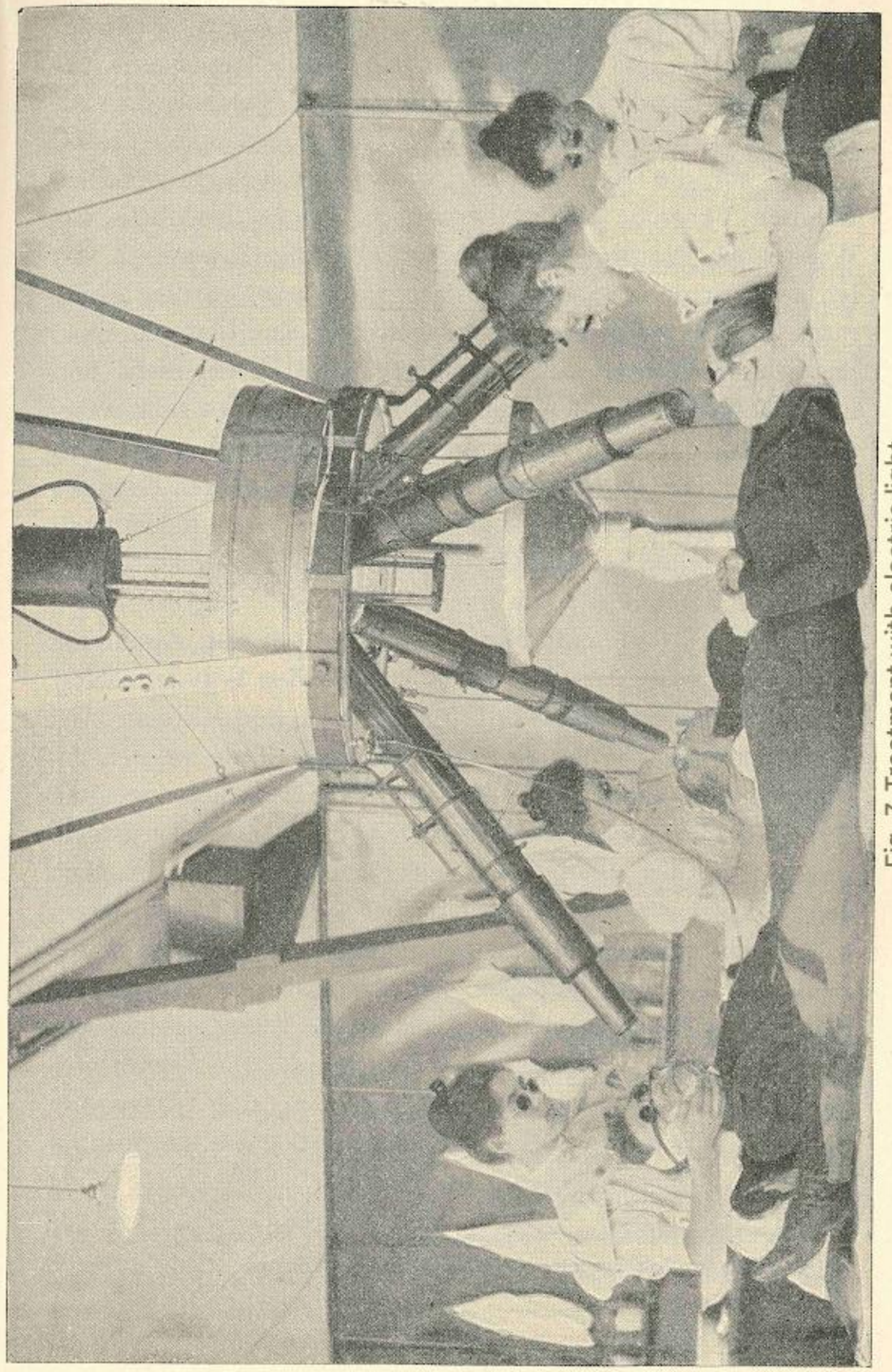

Fig. 7. Treatment with electric light

This allows the water in the container to cool without having to be replaced. The water inside the container should be distilled, while the cooling water is ordinary. The reason for attaching a so-called "cooling cap" to the apparatus is, as is clear from my above-mentioned experiments (p. 17), not that the water absorbs the heat rays better when it is cold, but rather that the water in the apparatus often becomes very warm, and as soon as a lens were to burst, the warm water would pour over the patient and possibly scald him; moreover, it is very likely that the apparatus would leak if the water became too hot. Since, for other reasons (as mentioned on p. 24), a water line had to be established for treatment, it did not require much effort to cool the collecting apparatus at the same time

The last change I made to the apparatus was that the tube forming the water container was designed so that it could be divided into two parts in the middle; the two parts are screwed together and kept watertight by a gutta-perchar ring placed between them. Even better, however, is what we have recently introduced: being able to take the tube apart at two points, directly next to the two lenses that close it.1 This change was made to facilitate the cleaning of the inner surfaces of the rock-crystal lenses, which seal off the water layer from above and below. The necessity of very careful cleaning and frequent renewal of the water in the container was shown in a very interesting

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This change was proposed at the same time by Professor von Petersen from St. Petersburg. — but independent of me.1 —

In the beginning, we only cleaned the lenses once a week, but it soon became apparent that the reaction was strongest the day after this cleaning; closer examination now revealed the necessity of frequent and careful cleaning in order to achieve the full benefit of the light.

Only very recently, I have provided the apparatus with a metal lid, which closes the lowest part of the

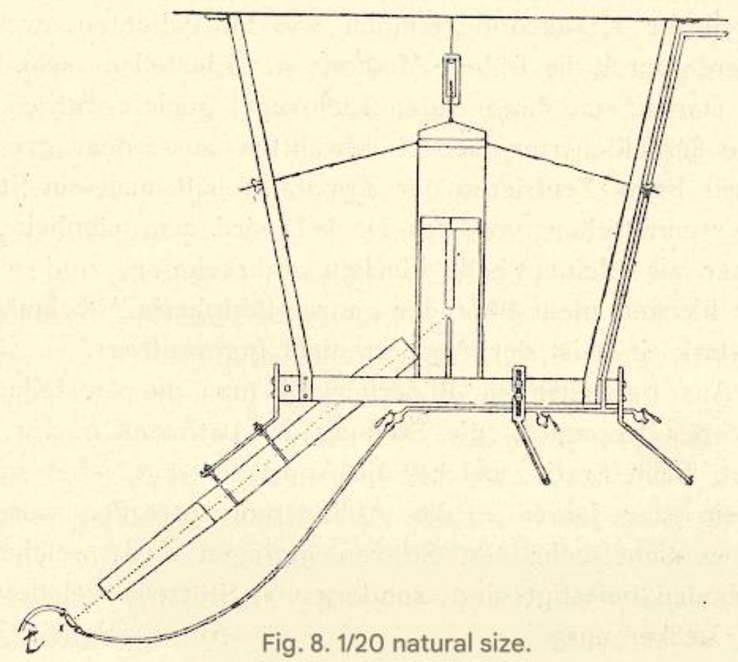

Fig. 8. 1/20 natural size.

tube, from which the light comes. The lid is similar to the one used to close a photographic camera; the only difference is that this lid is provided with a number of small holes. This lid serves to make it more convenient for the nurses to adjust the patients. Through the many small, regularly distributed holes,

Minimal amounts of light, whereby the same light image (focal point) appears as usual, only very dimly, so that one can easily observe it without dark glasses. The adjustment is much easier and more accurate in this way, and only when the affected area is in the correct position relative to the light and everything is in order is the cover removed and the full, strong light now falls on the patient. However small this improvement is, it represents a very great advantage for nurses as well as for patients, the latter of whom were very embarrassed by the strong and burning cone of light with the previous method of adjustment. These perforated covers also provided a great advantage in centering the apparatus; if one holds a piece of paper directly in front of the cover, one will perceive all — the holes as small, bright spots, and if these spots are not evenly bright over the entire periphery, the apparatus is not well centered

The accompanying pictures show the arrangement of the apparatus, the position of the patients, etc. A few years ago, a modification was made to the stand that supports the apparatus: it is no longer supported by supports fixed to the floor, but by supports extending from the ceiling, thus achieving greater stability and more space for the patients and nurses.

What is the difference between sunlight and electric light, and when should one use one and when the other?

The difference between sunlight and electric arc light, which is of practical importance to us, can

be briefly expressed as follows. 1. Sunlight contains relatively more heat rays compared to chemical rays than strong electric arc — light. 2. The maximum of the chemical rays of sunlight lies in a different part of the spectrum, namely closer to the red rays, than in electric arc light

The theoretical conclusion that can be drawn from point 1 is that electric arc light is better suited for treatment than sunlight. Since the conditions and means for propagating the heat rays are the same and the same for both types of light, one will consequently obtain, with the same degree of heat at the focal point,

— a stronger chemical effect from the light cone of electric light than from the sunlight cone. The degree of heat at the focal point of the light cone is decisive when it comes to how strong light can be used for treatment. For we do not yet know of any reason that speaks against the use of even the strongest light for treatment, and before we learn such a reason, we must naturally strive to achieve higher and higher intensity levels of chemical rays. However, it must be added here that these should be the type of chemical rays that have the property necessary for therapy of being able to penetrate deeply (see this later).

While the temperature of the light cone that the patient could tolerate without water trickling through the pressure apparatus was 50°C, after the introduction of water trickling, as discussed, it rose to slightly over 200°C

With the last-mentioned degree of heat as the upper limit, one can further examine how strong light is possible. Regarding sunlight, the standard is lacking, since it varies so much at different times of the day and the season. As stated above, I would like to assume that lenses with a diameter of approximately 25 cm are the most suitable.

Regarding electric light, one can come somewhat closer to determining it. Experience has shown that with ordinary arc light (carbon electrodes) and with my collecting apparatus discussed above, light stronger than approximately 70 amps cannot be used. At 80 amps, the light cone is so hot that many patients cannot tolerate the treatment.

A more detailed comparison of these two types of light will be discussed later, together with the evaluation of various other light sources and the various treatment apparatus. I will only cite a few details here from which one can somewhat see the difference

Based on studies we conducted with bacteria, I assume that, under otherwise identical conditions, it would take a few minutes to kill the Prodigiosus in plate culture with strong sunlight, while it would only take a few seconds with electric light.

With regard to the visible effect on the skin, I cannot give precise figures; in general, I can only say that daily experience in treating patients shows that they get a much stronger skin reaction from electric light than from sunlight. One can certainly also say that sunlight does not usually cause blisters, whereas it usually

is the case with electric light (treatment time is 5.5 hours). Incidentally, with regard to this question, I refer to my treatise ("New Investigations on the Effect of Light on the Skin." Reports from Finsen's Medical Light Institute I, p. 8). This contains a comparison (p. 14) of two experiments on my arm with unconcentrated sunlight and unconcentrated electric light. The result was that the inflammation induced on my skin after three hours of exposure to sunlight (the experiment was conducted from 12 p.m. to 3 a.m. in the first half of August) was not as severe as that caused by 20 minutes of continuous exposure to electric light (80 amp lamp, 50-75 cm distance).

From what I have presented here, one will be able to form a fairly clear picture of the superiority of electric light, and yet it is strangely the case that, with regard to lupus treatment, we at the Light Institute have not gained any definite impression that the results of treatment are worse at times when more sun treatment takes place than in winter, when we do not need sunlight; on the contrary, in any case, we have previously been inclined to attribute a more favorable effect on the patient and a more favorable course of treatment to sun treatment.1) Now, insofar as this assumption is correct, we are faced with an apparent difficulty in explaining it; but only apparently, for probability suggests that another factor is at work here, which-

1) This view, which is indeed a pure estimate, must now probably be modified somewhat

thing to consider: namely, the general condition of the patients. And it is a reliable experience that the general condition of our lupus patients is better in summer than in winter. This can be attributed partly to the same reasons that cause summer to be generally regarded as the most favorable time for patients with tuberculous diseases; but perhaps it is also due to the fact that local sun treatment is combined with exposure to the open air and sunshine and is thus a kind of general treatment in sunlight. Incidentally, one must remember that it is a general experience; we constantly hear it from our lupus patients that local affections often improve spontaneously in summer and worsen in winter. For these various reasons, one should therefore not be surprised that — One sun treatment apparently produces just as good or even better results in lupus vulgaris than the more powerful electric light The situation is quite different, however, with other skin diseases that we have treated with good success using concentrated light. In the treatment of lupus erythematosus, alopecia areata, and telangiectasias, the superiority of electric light is so evident that it would perhaps be most correct not to treat these diseases with sunlight at all. This difference in the effect on these various diseases is quite characteristic and can perhaps, with some justification, be regarded as a sign of the importance of the general condition for the improvement or cure of lupus vulgaris.2

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1 It might be possible that better results could be achieved through very long sessions. 2 After writing this, I thought about whether not.

The practical consequence of this difference in the effect of the two types of light—a difference which, as will be remembered, did not exist in the early years of this method, but is a result of the introduction of rock crystal instead of glass—is, of course, that we now need sunlight much less — frequently than before. The use of sunlight is limited to the brightest part of the year (May–September) and the brightest part of the day; in general, we only use sunlight when the weather permits outdoor treatment. The fact that we do not use sunlight in winter, or generally when the sun is low in the sky, is due to the fact that sunlight when the sun is low in the sky is not only absolutely but also relatively poorer in chemical rays than when the sun is high in the sky. This is due to the atmosphere, which has the property of absorbing significantly more chemical rays than heat rays

One gets a good impression of the extent to which this is the case when one examines the tables for the intensity of the sun's rays in Copenhagen, calculated by our physical collaborator, Mr. Absalon Larsen. A few figures will show it best. If we set the value of the heat effect of the direct sun's rays on June 21 at 12 noon, it is

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This relationship could perhaps be explained in another way, and is based on the difference between the two types of light (see: The different position in the spectrum of the maximum of the chemical rays). There is a lot of — evidence - we have unfortunately not yet investigated it more closely - that the less refractable the rays are, the more easily they penetrate into the depths of the tissue. The explanation could therefore be the stronger depth effect of sunlight than of electric light.

1) Absalon Larsen: The Intensity of the Sun's Rays, Reports from Finsen's Medical Light Institute I., p. 110

at 7 p.m. 34; if we set the value of the chemical intensity at 12 p.m. on the same day at 12 p.m. at 119, it is only 5 at 7 p.m. At 12 p.m. on December 21, we have approximately the same altitude of the sun as on 7 p.m. on June 21, and the numbers are therefore approximately the same: the heat effect 33 and the chemical intensity 4.

In the beginning, and before I knew these numbers, I believed I could compensate for the low power of sunlight in winter by using larger lenses, but as I tested the chemical effect of the light cone when it was as strong (i.e., warm) as the treatment allowed, it turned out that the chemical intensity was extraordinarily low; but only after the exact tables were available could I clearly assess the conditions

Even if one did not have precise physical investigations into these relationships, one could still be convinced of them through direct observation. As is well known, the sun is red when it is near the horizon and becomes whiter and whiter the higher it rises. This shows that the red rays, the heat rays, are in such extraordinary predominance when the sun is low in the sky. Conversely, the color of the sun actually becomes more and more blue the less atmosphere the light has to pass through, so that if one could observe it from a point outside the atmosphere, its color would appear blue (Langley).

With regard to our application of light, the difference between these two types of light has the technical significance that, as discussed in detail earlier on pages 8-9, it is most advantageous to use rock-crystal lenses for collecting apparatus for electric light and glass lenses for those for sunlight.

What possibilities exist for improving the method

first communication on this method, I emphasized that there was certainly the possibility of an extraordinarily great improvement in the method, both concerning the apparatus and the light itself. Although I have explained in the foregoing that over the past six years there have been great improvements in the light — Already source and the apparatus, especially the latter, there is — in my no doubt that the method can still be improved and will be significantly improved. I will briefly outline the directions in which development is likely to proceed.

The improvement in light will consist in creating a light that is as rich as possible in chemical rays and as poor as possible in thermal rays

With regard to sunlight, an improvement can only consist in seeking times and places where sunlight particularly fulfills the given conditions. I touched on this question earlier (p. 47) and showed that sunlight at our latitude is only suitable for light treatment at certain times of the year and day. These conditions must, of course, be known if one wishes to use sun treatment. The location of the place is also of great importance.

We know that the atmosphere mainly absorbs chemical rays; therefore, sunlight will be much better suited for treatment in places

where the air is light and pure, while places where the air is filled with dust particles and water vapor are less favorable. For these reasons, sunlight is generally stronger in the countryside than in large cities with their smoke-filled atmospheres, and even stronger in the interior of the country, where the air is comparatively dry, in contrast to the coast, where it contains significantly more water vapor

The greatest importance is attached to the altitude of the location above sea level; the higher the location, the thinner the layer of air the light must pass through, and the greater the chemical intensity of the light. Added to this is the advantage that the air temperature in high-altitude locations is not as high as that of low-altitude locations at the same latitude. Heat has great practical significance. Even here in Denmark, it is difficult enough for both nurses and patients to endure the heat in the middle of the day during sun treatment on warm summer days. The further south you go, the worse it becomes, of course. In Greece, for example, it has been shown that sun treatment must be postponed to the morning hours for this reason, while the sun is low in the sky. This, however, is disadvantageous because, as mentioned above, the chemical intensity of sunlight decreases relatively sharply when the sun is low in the sky

The disturbance caused by heat in this way is actually so great that, in practice, more favorable conditions for sun treatment exist in northern countries than in southern ones. If one could make such arrangements that nurses and patients would be protected from the sun and not suffer from the heat, while still

obtaining direct sunlight for the apparatus, it would be a different matter.

From this one can see that if it were a question of establishing a large light treatment facility or a sanatorium for lupus patients, especially in southern countries, it would be very expedient to locate them at high altitudes. Apart from the great economic importance of the use of sunlight compared to electric light, there is the advantage that, due to the great chemical intensity of the light, one could certainly achieve completely different favorable results in such a location than are possible with sunlight in our country The idea of establishing such an institution or sanatorium for skin tuberculosis on a mountain may not be so absurd at present, since sanatoriums for pulmonary tuberculosis are currently being built on mountains. Perhaps it would be most natural and easiest to combine such a lupus treatment institution with a phthisis sanatorium, since the latter might already have an electrical system for lighting. Collaboration would be easy here and could possibly even be achieved without any further electrical system, since the light treatment could take place during the day when there was no sun, since electricity is not used for lighting. At the same time, it would be a good opportunity for the not inconsiderable number of lupus patients who also suffer from pulmonary tuberculosis to be able to enjoy systematic pulmonary tuberculosis treatment. This combination of lupus treatment and phthisis treatment is already in practice at the local Light Institute, where, on Dr. Bang's initiative, we set up a lounge for lupus patients with chest disease.

at the same time, we have also strove to improve the nutritional status of the less well-off patients by distributing milk and hematin albumin. (Since the patients do not live at the institute, we could only partially concern ourselves with their nutrition.)

This suggestion of mountain lupus sanatoriums is certainly somewhat outside my subject, but may perhaps have practical interest now that so much can be done, and hopefully something will therefore be done for the unfortunate people who suffer from lupus, in the same way that is done for chest patients. And there can be no doubt that the disease is widespread enough in most countries to justify such comprehensive measures, since we have learned how widespread it is in Denmark, a country that is not particularly heavily tuberculous

But to return to my topic: the possibility of improving the light source, we are quite differently free when it comes to artificial light. Since this is of great importance, we have been working constantly on this task over the past few years. The investigations initially aimed to: 1. determine, by comparing different types of arc lamps, which was best suited for us. Accordingly, it was necessary to find out 2. whether the light from the arc or from the carbons was the best, and finally 3. at what voltage the light was most advantageous for our purpose. For this determination, we used partly chemical reagents (silver chloride and silver bromide paper) and partly bacteria. These latter are definitely the best and most practical means of determining the intensity of light, since they are precisely the most

The most bactericidal type of light is the one to be measured. Through a long series of such investigations, which I will not go into in detail, we have found that the ordinary arc lamp in the form we currently use, which was partly constructed according to our specifications, is preferable to all others we have tried.

To investigate whether the light from the arc or from the glowing, positive carbon tip is the most bactericidal, I formed an image of the arc and carbon with the help of a convex lens made of rock crystal and let it fall onto a plate culture of B. prodigiosus. The next day, the culture showed, just like a photograph, which parts of the light had the strongest effect on the plate culture. The least effect was found at the point of the arc, a somewhat stronger effect at the point of the negative carbon, but by far the strongest with the positive carbon. (This does not mean, however, that the ratio cannot be different with a different arc light.)

The voltage tests showed that the most favorable voltage for the lamp (approx. 50 volts) also produced the most bacteria-killing light.

The changes we made to the lamps are actually limited only to the external shape; for example, the distance between the side rods was made very large so that they would absorb as little light as possible. To prevent the lamp's regulating mechanism from overheating, an asbestos screen is attached over the carbons. Furthermore, the lamps are designed to be absolutely

can be screwed into the center of the ring that supports the apparatus.

The reason for such a cursory discussion of these investigations is that the Light Institute has recently been working diligently on new lamps with various types of electrodes. These lamps initially seemed to promise much, but did not live up to expectations. They have since taught us that more precise investigations into the ability of individual types of rays to penetrate tissue are necessary, and that there is little point in continuing to work on lamps until this question is completely clarified. In any case, all probability indicates that the future will bring better lamps, since the lamps currently in use are constructed only for the purpose of illumination, but not with the aim of causing inflammation and killing bacteria. Once it becomes clear to the experts in this field that they must construct something new for medical use, progress will surely follow

The second way to improve the method is to improve the apparatus. I have said a lot about this previously and will therefore be brief. Although the forms we currently use have emerged from the most careful investigations, it would be presumptuous to believe that they could not be improved in some respects.

--both the solar apparatus, the electrical collecting apparatus, and the printing apparatus, but what these improvements should consist of is not so easy to say at the moment. One of the most natural improvements, on which we have been working for some time, would be to treat a larger area at once, that is to say

to arrange the apparatus and lamps so that the light spots become larger without reducing the intensity of the light. With the usual apparatus with lenses of 7 cm diameter, one would have a spot of 7 cm in diameter, instead of the current one of 1/2 cm

Diameter, if one were to place a flat plate of rock crystal in the lowest part of the tube instead of a convex lens. To achieve the same effect, the intensity of the light must, of course, be significantly increased at the same time. Such an enlargement of the light spot would be very advantageous for widespread cases, but unnecessary for less widespread ones. We will therefore probably have apparatuses with light spots of different sizes in the future, so that, as we have already arranged, one has light spots of different intensities

very practical improvement was recently made by Dr. A Reyn. Since the lens closest to the light often cracks, Dr. Reyn came up with the idea of cooling it with water. This is done by placing a flat rock crystal plate 2 cm in front of the uppermost lens. In the space created by this, there is distilled water, which is constantly cooled by a water stream circulating around it. This prevents the precious lenses from cracking, but also brings the entire apparatus closer to the light, and this can thus be better utilized.

The Application of the Method in Practice.

While I have dealt exclusively with the physical part of the method in the previous section,

I will now proceed to give a description of the application of the method in practice, as well as a report on the therapeutic results achieved with its help to date.

As is clear from my first publication on this method, 1. c. 43-44, I was clear from the outset about the great potential for development that lay within it, both with regard to its technique and its therapeutic field, and although several of my assumptions and opinions turned out to be incorrect (e.g., at that time I believed I could achieve an enormous amount by using very large solar lenses, which, as mentioned above, was not the case), my hopes have not been disappointed

At that time (1896), fearing — that the method could only be judged by the relatively good results achieved at that time, I declared the following (1. c. p. 43): "A — judgment about the method from the current standpoint will therefore be entirely incorrect. Before experiments have been carried out with very strong light and the best possible apparatus, one will not be able to form a definite opinion about its real value." This raises the question of whether we are now at the point, or when we will reach the point, where we can consider the demands made to have been met. I will reply that I do not consider the method to have been even remotely fully developed before the introduction of rock-crystal apparatus and large arc lamps of 60-70 amps, which was only fully implemented in June 1898. The preceding period, i.e., from November 1895 to June 1898, must be described, as I do below, as the experimental stage

The separation of the experimental stage from the later stage takes on essential significance when the results of the treatment are discussed, while it plays no role, so to speak, with regard to the technique or execution of the treatment, which I will now discuss in more detail.

The execution of the treatment.

No very essential changes in the execution have been made, and the description I gave on 1. c. pp. 36-38 therefore still applies. The following changes have occurred

Each area is now treated for only 54 hours instead of 2 hours, and yet the effect is now much stronger than it was previously after 2 hours. This time (the 5/4 hours) is not absolute; it is the one currently used for lupus vulgaris, but it is very likely that experience will gradually show that for diseases successfully treated with this method, one can either be content with shorter séances or longer ones must be used. It may also be necessary later to individualize the duration of the séances for lupus vulgaris, since there is a significant individual difference in the intensity of the skin reaction. At present, we individualize by exposing patients, depending on their tolerance for light, to either the strongest or weakest lamps we use—70 or 45 amps, as appropriate for the purpose. They sometimes receive two applications in succession to the same area

At first, I let each nurse serve only one patient; but I hoped that later, when they were more experienced, each would be able to serve two patients

I tried it for a while, but gave it up again because it seemed to me that what was gained economically was lost again through poor maintenance. And now, after the introduction of the thin, long rock-crystal apparatus, which must be adjusted frequently, and the pressure glasses with water trickling through them, I consider it very wrong to have a nurse supervise more than one patient. In addition, the nurses can rarely leave the pressure glass entirely to the elastic band to which it is attached, but must hold it in the correct position and often exert pressure on it with their fingers, which would be impossible if the nurse in question were to attend to two patients

A greater difficulty than one might think is associated with the appropriate positioning of the patient. One might perhaps find that this point is of secondary importance and can be overlooked, but in reality, it is of great practical importance that the treatment is not burdensome for the patient. It is easy to understand how difficult it is to place the various diseased areas, especially the face and neck, under the cone of light so that the light falls fairly perpendicularly onto them and also so that the head is not simultaneously turned into an uncomfortable position. Since a séance lasts four hours, and one must keep the head in the same position during this time, it is naturally important to lie comfortably. This quick and easy positioning of the patient in a correct and comfortable position relative to the light is one of the most important, but at the same time most difficult, tasks of our nurses. The most practical method has proven to be to place the patient on a bed with adjustable

Head end shown (the shape we use in hospitals for bandaging). The finer adjustment of the head, in order to bring the affected area under the focal point of the light cone, is achieved with the help of differently shaped pillows. In many cases, when the patient can be treated most easily in a sitting position or prefers to sit, we use rocking chairs with great advantage, as they can be adjusted with the help of wooden blocks that are pushed under the aisles. One could certainly construct special chairs that would be even better and adjustable in all directions, but they would be considerably more expensive and would provide little benefit in comparison.

The effect of the treatment

Since light treatment already encompasses a considerable range of skin diseases and is constantly expanding its indications, the description of the treatment and its effects should have a general character. However, since our experience with lupus vulgaris is much greater than with all other diseases combined, I will prefer to give a detailed description of the treatment and its effects in this disease as a paradigm and add what is particularly noteworthy later when discussing the other diseases.

The treatment currently proceeds by illuminating a small, round spot (2-3 cm in diameter) for 5/4 hours daily. To ensure that the nurse does not make a mistake regarding the location and to ensure that the light cone consistently aims at exactly the same spot, the physician usually draws a

with a dermatograph, a ring is drawn outside the area to be treated. Since we have the powerful rock crystal apparatus and the strong light, the same spot is generally no longer treated several days in a row as before, when there is enough diseased tissue to choose a different spot. The reaction is often so severe that it cannot be treated well. There are great individual differences here, for while some patients with lupus so small that there is only room for one spot can tolerate the treatment for many days in a row, others have to take a break of one or more days between each treatment.

visible effect of the treatment on the skin is severe reddening of the spot, and the spot rises above the surrounding skin; vesicles often, one could say almost always, form on the spot The time of its formation varies, between 16 and 24 hours after illumination. This vesicle formation, which sometimes takes on smaller, sometimes larger dimensions, is very similar to the vesicles after vesicatories. Vesicle formation occurs much more frequently and strongly after electric light than after sunlight. In individual cases, the reaction on the treated area is so severe that a slight edema occurs in the surrounding skin, especially if the area is in the The region of the eyes. Incidentally, one can usually judge from the extent of the skin reaction whether the apparatus and the light are functioning properly; if the reaction is very slight, there is reason to assume that something was wrong with the lamp or the apparatus; in this way, as mentioned above, we have learned that very frequent cleaning of the apparatus is necessary.

The reaction acquires a second practical interest in that it makes it possible to check whether the nurse had been careful or not. If, for example, the spot is very blurred, or there are possibly two red spots on the skin, this proves that the light cone was not always in the same place during the entire séance.

The further course of this skin reaction is: drying of the vesicles and formation of a scab, which falls off after a few days, after which new epidermis is seen forming over the entire area. This course is constant. Thus, the light treatment does not produce any necrosis of the skin, and no scar tissue forms or occurs as a result of the treatment; the new epidermis is formed simultaneously from the entire base of the spot where blister formation has occurred

— In my first treatise, 1. c. p. 39, I once mentioned having observed necrosis after light treatment, which was due to a pure burn; I must add here that I later observed only a very isolated case of this. If one considers that the necrosis of the lupus tissue was intentionally induced in various previous treatments, one will not attach any detrimental significance to these individual cases, especially since they were usually caused by the patients' lack of attention, in that they did not report that the light was burning.

I will add, incidentally, that I intentionally used this ratio experimentally on several occasions. I was dealing with a few isolated lupus nodules that had been very resistant to light treatment; I

therefore suggested to the patients that they try burning away the wound with the help of the light cone, that is, applying the warmth of the light simultaneously with the chemical rays. By applying strong pressure with the pressure device, the process became less painful, and the patients endured it quite easily. But the result did not meet my expectations; on the contrary, instead of disappearing, the affection seemed to spread, and when one takes into account the painful nature of the treatment and the loss of substance during wound formation, the result of these experiments was actually proof of the great advantage of "cold" light.

A significant consequence of the peculiarity of light treatment not to produce a scar and therefore also to be applied to healthy skin without disadvantage is, as I mentioned right at the beginning (1. c. p. 40), that the apparently healthy, but possibly infected area surrounding the diseased area can be treated. In this respect, light treatment has an inestimable advantage over many other methods that may otherwise be rational

Now that the affected area and the surrounding healthy edge have been thoroughly treated, a change in the affected parts becomes apparent; any ulcerations are healed, the surface becomes firm and smooth, and upon diaphanoscopic examination, it is seen that the characteristic lupus nodules become fewer and fewer, finally disappearing completely. Meanwhile, the skin remains red on the treated areas for some time, but gradually becomes pale and regains its natural color.

This process of change naturally takes a certain amount of time; how long is impossible to say, since there is such extraordinarily large individual variation

and therefore a certain amount of time must pass before one can truly see the effect of the treatment and determine whether the healing is complete or whether diseased spots still remain For this reason, to save time and unnecessary treatment, we have arranged for treatment to be discontinued for one or more months once the diseased areas have been thoroughly treated and appear to have improved significantly. During this time, a clear distinction is usually made between the healed and the not-yet-healed areas. The patient is then treated again, but this time usually for a much shorter period, followed by another break, and then possibly a new treatment, until finally nothing remains. It is not uncommon for the patient to be completely cured after the first treatment, but this usually requires several treatments. I will illustrate the situation in our case in the statistics below. It is self-evident, however, that such statistics can only be valid for a single clinic or a single doctor, since it depends greatly on how long and how thoroughly the first treatment was carried out. The statistics also show that many patients have had to resume treatment numerous times, but this is also the worst possible outcome. The treatment is as effective in lupus vulgaris as can be expected. The fact that among our more than 800 cases, there are nevertheless a few in whom the effect of the treatment was very slight can perhaps be blamed not so much on the method as on other fortuitous circumstances.

Since it was important to me to make the experiments with this new method as pure as possible right from the start, so that they excluded any doubt, I used only light treatment in the treatment of the first 130 patients. Later, in individual cases, we advantageously applied other, older treatment methods, galvanocaustic therapy, — ointment treatment (especially Pyrogallus ointment), etc., before the light treatment, and then continued and concluded with the light treatment. How frequently we used this combined treatment method is shown in the statistics below. The cases in which we used this preliminary treatment were primarily cases with thick, spongy granulation formations, with heavily pigmented, thickened lupus areas, and the like. It has been shown that such preliminary treatment significantly accelerated healing in many cases; it paved the way for the healing light treatment The cases that make light treatment difficult to manage are, naturally, partly the very thick, deep-seated affections, partly the heavily pigmented forms. I must also add that we only need these strong agents for preliminary treatment in cases where the cosmetic result cannot be influenced by them, as well as where less important than rapid healing is required (e.g., on the trunk or the extremities).

In recent years, after the introduction of rock-crystal apparatus and since the effects on the skin have become stronger and the formation of vesicles has become more frequent, we have, in order to protect these excoriations caused by the treatment, treated patients with boric water.

1) Since the spring of 1898, patient treatment has been directed by Dr. Forch-Hammer as senior physician, with Dr. Reyn as secondary physician.

beatings, which incidentally also serve the purpose of softening the scab and thereby making the affected parts more accessible for light treatment. We also often need Diachylon and other healing ointments. 1)

(Continued.)

1) Since the above was printed (it had been ready for some time), a number of new lamps and new apparatus have appeared. I have not been able to discuss them here, but will go into them in more detail below by comparing them with each other and with my apparatus.

On the absorption of ultraviolet rays by blue liquids. By Valdemar Bie.

As described on pages 14 and 18 in Prof. Finsen's previous treatise, he originally treated patients with electric light concentrated through glass lenses and cooled by passing through a blue, ammoniacal copper sulfate solution. Simultaneously with the introduction of rock-crystal lenses, he replaced this blue solution with water because some preliminary experiments showed that the blue liquid absorbed ultraviolet rays, thereby losing the advantage of rock-crystal lenses. These preliminary experiments have remained for the time being. Since it is naturally of great importance to know for sure whether the chemical effect of light is so reduced by passage through a blue solution that the cooled electric light is unusable in practice, I conducted some experiments at Prof. Finsen's request to investigate this relationship more closely

The light from a 25 amp, 48-50 volt arc lamp was concentrated by a Finsen concentrating apparatus with rock crystal lenses. The first lens was 7 cm in diameter and 1.5 cm from the carbon tips.

A small stand was attached to the part of the concentrating apparatus facing away from the lamp, on which the rock crystal dishes containing bacteria mentioned below were placed, and a brass plate was suspended from a suspension bracket to block the light

This concentrated light passed through a light filter made of rock crystal or glass, which was filled with either distilled water or a copper sulfate solution (12% solution to which 1 cm^3 of ammonia water was added for every 10 cm^3). Both light filters had a lumen of 25 mm. The glass plates were 2.7 mm thick, the rock crystal plates 1.7 mm. The front surface of the filter was 40 mm from the nearest lens of the concentrating apparatus. The light cone had a diameter of 25 mm at this point.

the light had passed through the light filter, it struck previously After treated bacteria in the following way: A broth culture of B. prodigiosus (15 hours old in the first experiment, 18 hours old in the second) was filtered through filter paper. 1 cm^3 of this was diluted with 9 cm^3 of water Drops of this suspension were transferred to the rock crystal plate, which was enclosed in a brass ring, so that the plate and ring together formed a dish. A drop was placed on each plate and dried in a desiccator with calcium chloride. The bacteria were then illuminated under the conditions specified above. The rock crystal plate was placed 130 mm from the nearest lens; at this point, the light cone had a diameter of 12.5 mm. During illumination, cold water continuously flowed over the side of the rock crystal plate facing the light; the bacteria were placed on the opposite side of the plate. After illumination, I covered the dried bacteria with a drop of agar. The

Finally, the dishes were placed with the bottom (rock crystal plate) facing up on moist filter paper in a Petri dish, forming a moist chamber.

By doing this, I avoided the very significant source of error represented by the absorption of chemical rays by the culture media

When a saline solution, bacterial suspension, or something similar dries, a narrow, raised rim forms around the periphery of the dried drop. If this is covered with a drop of agar, as I did in this experiment, and the bacteria are allowed to grow, the growth in this rim becomes denser than within it. If the bacteria are illuminated, those in the small area inside the rim are killed first, whereas those in the edge later. The destruction of the bacteria in this raised rim proceeds irregularly, as expected. When reading the experimental results, I therefore only considered the part of the dried drop that lies within the rim.

I. Rock crystal light filter with distilled water.

	Experiment I	Experiment II
1 sec.	Growth	
2 ,, ...	do.	
4 ,, ...	do.	Growth no
7 ,, ...	no growth do	growth do. do. do.
10 ,, ...		
15 ,, ...		
20 ,, ...		

II. Rock crystal light filter with copper sulfate solution.

	Experiment I	Experiment II
14 min.	Growth do.	
1/2 ,, ...		
1 ,, ...	do.	Growth do. no
2 ,, ...	do.	no
4 ,, ...	no growth	growth \ do.
7 ,, ...		
10 ,, ...		do.

III. Glass light filter with water.

	Experiment I	Experiment II
1/4 Min.	growth do.	
1/2 ,, ...		growth do.
1 ,, ...		
2 ,, ...	no growth do. do.	no growth do. do.
4 ,, ...		
6 ,, ...		

IV. Glass light filter with copper sulfate solution.

	Experiment I	Experiment II
1/4 Min.	growth	
1/2 ,, ...	do.	
1 ,, ...	do.	growth do.
2 ,, ...	do.	
4 ,, ...	no growth	no growth do. do.
7 ,, ...		
10 ,, ...		

The result of the experiments is that the bacteria are killed under the given conditions

when the light has passed through rock crystal and distilled water: in 4-7 seconds;

when the light has passed through glass and distilled water: in 1-2 minutes;

when the light has passed through rock crystal and copper sulfate solution: in 2-4 minutes;

when the light has passed through glass and copper sulfate solution: in 2-4 minutes.

The significant difference I found after light passed through rock crystal with distilled water, or through glass with distilled water, is due to the absorption of ultraviolet rays by the glass. The difference between glass with distilled water and glass with copper sulfate solution is due to the absorption of blue and violet rays by the same. I found no difference between copper sulfate solution in rock crystal and in glass. In other words, a copper sulfate solution of a given strength absorbs so many chemical rays that the difference in using rock crystal instead of glass is lost as soon as the light passes through the solution.

Investigations into the effect of light on smallpox vaccine. By Niels R.

Finsen

and Georg Dreyer.

The great influence that light has on the course of skin affection in smallpox must arouse astonishment. First, there is reason to be amazed that ordinary daylight can have such a powerful effect that the mere exclusion of chemical rays is sufficient to prevent the appearance of one of the most terrible disease states known to us (the suppuration stage). Second, there is every reason for astonishment in our bacteriological age that precisely the exclusion of a bactericidal agent has this effect in an infectious disease. If one were to draw the following conclusion: since smallpox is an infectious disease, it should seem rational to keep patients lying in strong light, and preferably in blue light, since this has a particularly bactericidal effect, then, from a purely theoretical standpoint, one would not have much objection to this view

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Such an objection has actually also been made against the treatment of smallpox by excluding chemical rays. The English physician, Dr. Moir,

who polemicized against this treatment in The Lancet — without having tried it, bases his argument exclusively on the above conclusion. Dr. M. ended his article with the words that the motto for smallpox treatment is precisely: "light, light, more light."

Experience gained has since become more valuable than theory, and this has not proven Dr. Moir right. Incidentally, the method was by no means lacking a theoretical foundation; it only had the flaw of not entirely fitting the dominant bacteriological standpoint of the time. Its correctness is demonstrated by the numerous and consistent results achieved with red light treatment, and one must admit: in the case of smallpox, the inflammation-inducing effect of light is much more important than its bactericidal effect

There was also the possibility that the pathogens in smallpox reacted differently to the effects of light than other microorganisms; at least, some investigations[2]) carried out at the Vaccination Institute in Hanover seem to indicate this. These showed that as soon as animal smallpox vaccine was enclosed in capillary tubes and exposed to scattered daylight or even sunlight for 2-8 weeks, the effectiveness of the lymph nevertheless remained unchanged.

Since it seemed to us that the solution to this question was of some interest, we subjected it to further investigation.[3])

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1) John Moir. Treatment of small pox by exclusion of the chemical rays of daylight. The Lancet, September 29, 1894, p. 739. 2)

Medical Statistical Report, from the Imperial Health Office. Vol. 5, Issue 2, p. 94.

3) The investigations were carried out by G. Dreyer

The experimental setup.

An electric arc lamp was used as the light source, and a Finsen concentrating apparatus with rock crystal lenses was used to concentrate the light.

The diameter of the positive and negative carbons was 2.4 and 1.5 cm, respectively. The tip of the positive carbon was always at a distance of 11.5 cm from the nearest lens of the concentrating apparatus. At the beginning of each series of experiments, new carbon (of the same length) was inserted. For all experiments, the arc lamp burned at 25 amps and 49-50 volts. During the experiments, the direction of the light was always 450° to the horizontal plane, and the illuminated area was perpendicular to the direction of the beam

The animal smallpox vaccine (ordinary glycerin emulsion) used for illumination was very willingly donated to the Light Institute by the Royal Vaccination Institute, just as the institute also kindly undertook the considerable task of carrying out vaccinations with the illuminated vaccine. This is of great importance, as it requires considerable routine to achieve consistent and reliable results. We therefore request our warmest thanks from the institute and its director, Corps Physician Dr. Bondesen, for their cooperation.

The vaccine to be illuminated was applied as a drop to a flat rock crystal plate set in a brass ring using a platinum wire eyelet with a diameter of 3.5 mm. (The thickness of the platinum wire was 0.2 mm). The greatest thickness of the drop was approximately 0.4 mm in almost all test series; test series 1 and 2 (approx

0.3 mm) and 12 and 13 (approx. 0.5 mm) excepted. The drops are always placed in the middle of the rock crystal plate, on the side facing away from the light source. During illumination, the rays were applied in such a way that the center of the rock crystal plate was centrally located in a part of the light cone that contained the strongest chemical rays (tested with silver paper). The diameter of the light cone here was approximately 1.2 cm.

Under illumination, the uncovered dishes were sprinkled with cold water to eliminate the effect of heat.

Where experiments were carried out with clear, blue, or red glass to exclude certain parts of the spectrum, this was done by placing one of the aforementioned glass plates between the light source and the rock crystal plate. Both plates were sprinkled with cold water

After illumination, one child was vaccinated with each drop through three tears on the left arm. In all cases, a control vaccination was administered to the child's right arm using unilluminated vaccine from the same glass tube. The control vaccinations on the right arm (also 3 superficial tears) resulted in the development of 3 vaccine pustules (1 for each tear) of normal, typical shape and size (c: strong success), which makes these control vaccinations particularly suitable for comparison. The examination of the vaccinated children was carried out on the weekday following vaccination.

The vaccine from 12 different calves was used in the experiments. The age of the vaccine varied between 1 and 4 weeks

The same series of experiments was always carried out on the same day with the same vaccine, and the individual experiments were carried out in immediate succession. The abbreviations used in the attached tables are as follows:

3 vaccine pustules of normal size: strong success.
3 of less than normal size: moderate success.
,, 3 of small size: weak ɔ : success.
,, 3 of insignificant size: abortive
Success

Test series I: Vaccine from calf 26. Age of vaccine: 15 days. Illumination through rock crystal. Largest thickness of the drop approx. 0.3 mm. Vaccination on 9 children.

Test No	Illumination time	Child No.	Number of cracks	Vaccination result
1	1 sec.	1	3	Strong success (3 pustules)
2	2.0	2	3	2 ,, (3 ,,)
3	3.0	3	3 (3	,, ,, (pustules)
4	5.0	4	3	2 (3 ,, (pustules) ,,
5	10	5	3	Moderate success (3 pustules)
6	25.0	6	3	,, ,, (3
7	50	7	3	abortive success (3 pustules)
8	100			8 3 no success
9	200 9 3 no			

Series of Experiments II: Vaccine from calf 30. Age of vaccine: 15 days. Illumination through rock crystal. Largest thickness of the drop approx. 0.3 mm. Vaccination on 9 children.

Experiment No.	Illumination time	Child No.	Number of cracks	Result of vaccination
1	1 sec.	10	3	Strong success (3 pustules)
2	2	11	3	,, (3)
3	3	12	3	,, ,, (3)
4	5	13	3	,, (3)
5	10	14	3	Moderate success (3 pustules)
6	25	15	3	,, ,, (3)
7	50	16	3	No success
8	100 ,,	17	3	,, ,,
9	200	18	3	,, ,,

Test series III: Vaccine from calf 37. Age of vaccine: 16 days. Illumination through rock crystal. Largest thickness of the drop approx. 0.4 mm. Vaccination on 9 children.

Attempt no.	Illumination time	Child No.	Number of cracks	Vaccination result
1	50 sec.	19	3	Moderate success (2 pustules)
2	50.0	20	3	20 — ,,
3	60.0	21	3	,, (3 (separated
4	60.0	22	3	(separated
5	75.0	23	3	weak success (3) ,,)
6	75	24	3	,, (3)
7	100	25	3	abortive success (1)
8	100 ,,	26	3	(1) ,,)
9	100	27	3	,, (1)

Experiment Series IV: Vaccine from calf 37. Age of vaccine: 23 days. Illumination through rock crystal and red glass. Largest thickness of the drop approx. 0.4 mm. Vaccination of 6 children.

Ver- Experiment No.	Illumination time Rock- red crystal	glass	Child No.	Number of cracks	Result of vaccination
1	75 sec.		28	3	weak success (2 P.)
2	100 ,,		29	3	moderate success (2 P.)
3	150 ,,		30	3	weak success (2,,)
4	200 ,,		31	3	no ,,
5		15 M.	32	3	strong (3 ,, P.)
6		30 ,,	33	3	,, ,, (3 ,,)

Test Series V: Vaccine from calf 37. Age of vaccine: 16 days. Illumination through rock crystal. Greatest thickness of the drop approx. 0.4 mm. Vaccination of 2 children.

Experiment No.	Illumination ting time	Child No.	Number of cracks	Result of vaccination
	I 120 sec.	34 3		Abortive success (1 P.)
	,,	2		120 35 3 No success

Experiment Series VI: Vaccine from calf 39. Age of vaccine: 10 days. Illumination through rock crystal. Largest thickness of the drop approx. 0.4 mm. Vaccination of 4 children.

Experiment No.	Illumination time	Child No.	Number of cracks	Result of vaccination
1	100 sec.	36	3	Abortive success (1 P.)
2	100 ,,	37	3	,, ,, (1 ,,)
3	200 ,,	38	3	no success
4	200 ,,	39	3	no " ,,

Experimental series VII: Vaccine from calf 2. Age of vaccine: 16 days. Illumination through rock crystal, clear and blue glass. Largest thickness of the drop approx. 0.4 mm. Vaccination on 6 children.

In- attempt No	Illumination time Rock crystal	clear blue glass		Child No.	Number of cracks	Result of vaccination
1	200 sec.			40	3	Abortive success (1 P.)
2	200 ,,			41	3	,, ,, (1 ,,)
3		5 M.		42	3	strong ,, (3.,)
4		10 ,,		43	3	,, ,, (3.,)
5			5 M.	44	3	,, ,, (3.,)
6			10 ,,	45	3	,, ,, (3.,)

Test Series VIII: Vaccine from calf 3. Age of vaccine: 9 days. Illumination through rock crystal, clear

and blue glass. Largest thickness of the drop approx. 0.4 mm. Vaccination of 10 children.

Test No.	Illumination time: Rock crystal	Clear glass	Blue glass	Child No.	Number of cracks	Vaccination result
1	200 sec.			46	3	No success
2	200 sec.			47	3	,, ,,
3		5 M.		48	3	Strong success (3 P.)
4		5		49	3	,, ,, (3)
5		10		50	3	moderate ,, (3)
6		10		51	3	,, ,, (3)
7			5.52		3	strong ,, (3)
8			5	53	3	,, ,, (3)
9			10	54	3	moderate infection (2 points)
10			10 ,,	55	3	,, and (2)

Experiment series IX: Vaccine from calf 3. Age of vaccination: 16 days. Illumination through rock crystal. Largest thickness of the drop approx. 0.4 mm. Vaccination of 8 children.

Attempt No.	Illumination ting time	Child No.	An- number cracks	Vaccination result
1	125 sec.	56	3	no success
2	125	57	3	,, ,,
3	150	58	3	,, ,,
4	150	59	3	,, ,,
5	175	60	3	,, ,,
6	175	61	3	,, ,,
7	200	62	3	,, ,,
8	200 ,,	63	3	,, ,,

Test series X: Vaccine from calf 4. Age of vaccine: 18 days. Illumination through rock crystal, clear and blue glass. Largest thickness of the drop approx. 0.4 mm. Vaccination of 10 children.

Test No.	Illumination time: Rock crystal	Clear glass	blue glass	Child No.	Number of cracks	Vaccination result
1	200 sec			64	3	no success
2	200 ,,			65	3	abortive infection (1 point)
3		15 points		66	3	weak infection (3 points)
4		15		67	3	(2 points)
5		20 ,,		68	3	no success
6		20		69	3	abortive infection (1 point)
7			15M.	70	3	no success
8			15	71	3	,, ,,
9			20	72	3	,, ,,
10			20	73	3	,, ,,

Experiment Series XI: Vaccine from calf 5. Age of vaccine: 21 days. Illumination through rock crystal. Greatest thickness of the drop approx. 0.4 mm. Vaccination of 12 children.

Experiment No.	Illumination time	Child No.	Number of cracks	Result of vaccination
1	35 sec.	74	3	moderate success (2 P.)
2	50	75	3	,, (2.0)
3	65	76	3	(3.0)
4	80	77	3	,, ,, (3.0)
5	95	78	3	(3)
6	110.0	79	3	,, (2.0)
7	125 ,,	80	3	,, ,, (3 ,,)
8	140 ,,	81	3	No success
9	155 ,,	82	3	Weak success (2 P.)
10	170 ,,	83	3	,, (3,,)
11	185 ,,	84		,, 3 (2,,)
	12,200 "	85	3	No success

Experiment Series XII: Vaccine from calf 10. Age of vaccine: 5 days. Illumination through rock crystal, clear and blue glass. Greatest thickness of the drop approx. 0.5 mm. Vaccination of 10 children.

Experiment No.	Illumination time: Rock crystal	Clear glass	Blue glass	Child No.	Number of cracks	Result of vaccination
1	200 sec.			86	3	Weak ex. (1 P.)
2	200 ,,			87	3	moderate success (1.0)
3		15 M.		88	3	strong success (3 P.)
4		15		89	3	(3.0)
5		20 ,,		90	3	moderate success (2 P.)
6		20		91	3	,, ,, (1.0)
7			15 M.	92	3	(3.0)
8			15	93	3	,, (3.0)
9			20	94	3	,, ,, (2.0)
10			(20.0)	95	3	,, (2 ,,)

Experiment Series XIII: Vaccine from calf 7. Age of vaccine: 26 days. Illumination through rock crystal, clear, blue, and red glass. Greatest thickness of the drop approx. 0.5 mm. Vaccination of 8 children.

Ver- Experiment No.	Illumination time: Rock crystal	Clear glass	Blue glass	Red glass	Child No.	Number Cracks	Result of vaccination
1	150 sec.				96	3	Weak. E. (3 P.)
2	200 ,,				97	3	Abortive. E. (1 P.)
3		15 M			98	3	Strong E. (3 P.)
4		20			99	3	Medium E. (1 P.)
5			15 M.		100	3	,, ,, (2)
6			20 ,,		101	3	and (3)
7				20 M.	102	3	Strong E. (3)
8				30	103	3	,, and (3)

The experimental tables show that vaccines, illuminated by rock crystal under the above-mentioned conditions, are not visibly affected by an illumination time of less than 10 seconds.

With illumination for a time of 10-100 seconds, a significant weakening, sometimes even complete destruction, occurs.

With illumination by ICO-200 seconds, very severe weakening or total destruction occurs. An illumination time of 200 seconds must be considered sufficient under the above-mentioned conditions to almost certainly lead to the total elimination of the vaccine's ability to produce vaccine pustules.

For comparison, I will only note that a Prodigiosus culture, dried onto an approximately 0.3 mm thick agar layer and thus illuminated under exactly the same conditions, was killed after 40 seconds of light exposure

experiments also show that small variations in the thickness of the illuminated layer are of great importance. Experiment series I and II therefore show the destruction of the vaccine after 100 The seconds of illumination, whereas in experiment series XII and XIII even 200 seconds of illumination caused absolutely no destruction; we find similar conditions when certain parts of the spectrum were excluded (experiment series XII and XIII).

Experiments IV, VII, VIII, X, XII, and XIII show that the destruction of the vaccine, as well as that of bacteria, is mainly due to the effect of ultraviolet rays.

However, 5 minutes of illumination through clear and blue glass, which retains a large part of the ultraviolet rays, has no demonstrable effect. Only

Illumination through clear and blue glass for 10 minutes results in attenuation, and it requires an illumination time of 15-20 minutes to produce severe attenuation or destruction.

The relationship is even clearer if the illumination takes place through dark-red glass, which retains all chemical rays, since not even 30 minutes of illumination has a demonstrable effect on the virulence of the vaccine.

The slight variations exhibited by some experiments can, of course, be explained by small differences in the experimental procedure, which are almost impossible to avoid, such as slight variations in light intensity, droplet thickness, etc.

It has not been possible to establish any difference in the effect of light on vaccines from different calves

It has often been pointed out before [1]) that temperatures of 30-40°C have a weakening effect on smallpox vaccines and reduce the duration of their ability to produce pustules. Since it has now been shown here that strong light also has a very harmful effect, the same precautions must be observed when storing vaccines as with known bacteria and their toxins, and they should therefore be kept in the cold and dark (possibly in red glass).

1) Lemoine: Compt. rend. de la Soc. de Biologie. No. 12, p. 321

On the Production of Arc Light with the Aid of Cooled Electrodes. By Sophus Bang.

Since Finsen pointed out the therapeutic application of "chemical" rays of light, a number of experiments have been carried out, both here and abroad, to produce such rays in larger quantities and more cheaply than before. These experiments have partly been based on utilizing the ordinary carbon arc light in ways other than those used by Finsen; partly, the application or production of new light sources with a greater abundance of chemical rays has been attempted. I will briefly discuss only these latter endeavors here

Since many metal spectra contain a great wealth of short-wave, and therefore strongly chemically active, rays, it is understandable that particular attention has been focused on these. As early as 1896, Finsen described an experiment he carried out in this direction following Prof. La Cour's suggestion. He used calcium to insert a mixture of lime and graphite into a bore of the positive electrode, which, as usual,

1) "On the Application of Concentrated Chemical Rays in Medicine", p. 46.

consisted of carbon. The light produced in this way proved to be very rich in chemical rays; but the experimental results were not put into practical use at that time, particularly because the glass collecting apparatus used at that time made the usefulness of the produced ultraviolet rays illusory. A year later, I tried using magnesium, partly as a metal, partly in various compounds; The richness of light in ultraviolet rays can also be increased in this way, but it has never been applied in practice. Magnus Moller 1) used a zinc wick in his experiments on ultraviolet rays. Later, Strebel 2) proposed the use of aluminum oxide and silicate, as well as zirconium, in addition to the materials mentioned. He also used electrodes made of metallic cadmium, aluminum, and zinc, causing high-voltage induction sparks to jump between the poles of these metals, thereby obtaining a light extremely rich in ultraviolet rays. An experiment with mercury as the positive pole and carbon as the negative pole, using a direct current, was conducted in the winter of 1900-1901 at Finsen's Light Institute by Kjeldsen, using the mercury lamps of Arøn and Hewitt as a starting point. This method also produced a light extraordinarily rich in ultraviolet rays.

One metal that should be particularly interesting to experiment with due to its richness of spectral lines is iron. This was discovered in an electric lamp for therapeutic use by the Russian physician

1) MAGNUS MÖLLER: The Influence of Light on the Skin etc., Stuttgart 1900.

2) Deutsche med. Wochenschrift, Nos. 5-6, 1901

EWALD[1]), who in 1895 believed he had made the observation that the workers in the ironworks in Kolomna (Moscow Government), who were engaged in welding iron together using electric current, were spared from certain illnesses, such as rheumatism. He therefore manufactured a lamp whose positive pole consisted of cast iron and whose negative pole consisted of a carbon rod: 2-300 amps. Kosloffski later used EWALD's lamp at a private clinic in St. Petersburg. The patients
had to be placed at a distance of 1.5 meters from the arc, since the radiation from the molten iron was unbearable at shorter distances. A current of The parts of the patient that were not to be treated were protected by screens. The séances lasted from 3/4 to 2 minutes and resulted in skin erythema

The use of metals as high-current electrodes is now associated with practical difficulties, as the metal melts and splashes, so the patient must be placed at a great distance from the light source. This also makes lamp regulation more difficult. In May 1901, I came up with the idea of cooling the electrodes with water to eliminate these disadvantages. I had acquired an X-ray lamp with a water-cooled anticathode for use in the Light Institute; it now seemed logical to also try water-cooling the conventional direct-current electrodes. By forming an arc between two iron tubes through which water flows, it was shown that a steadily burning arc light with the properties mentioned below could be obtained.

1) See Kernig: Experiences on the Effects of Intensive Electric Light. Journal of Dietary and Physical Therapy, 1899, Vol. 2, p. 238

Incidentally, a closer examination of the literature revealed that W. Siemens had already used a water-cooled metal electrode in an arc lamp in 1879. While the positive pole was made of carbon, the negative pole was formed from a gilded metal capsule, the interior of which was cooled by a water stream. This resulted in only minimal wear on the electrodes, which was necessary for the regulation mechanism of the lamp in question; however, a change in the properties of the light through this cooling was not observed. As I will discuss in more detail later, it is also particularly when the positive electrode is cooled that the light changes its character

The cooling of the electrodes can be accomplished in several different ways. For lower currents (under 20 amps), I have generally preferred internal cooling by giving the metal in question the shape of a sleeve that can be screwed onto a double-walled tube with water circulation. For higher currents, it is more practical, at least for the positive pole, to use external cooling by placing the electrodes in a vessel containing flowing water so that only their tips protrude above the water. In individual cases, it is advantageous to place the electrode tips just at the water surface, or even a millimeter below it, which changes the spectral character of the light but does not prevent arc formation. Under all circumstances, the coolant must act on the electrodes very close to the pole faces; for iron, the distance should not exceed 3 mm; for metals with better thermal conductivity, it can be somewhat larger

The most striking effect of cooling, as far as the positive electrodes are concerned, is observed through the suppression, or at least through a minimized, "crater formation." This is clearly seen when cooled carbon is used. Due to the suppression of the thermal transition effect at the positive pole surface, the carbon becomes convex instead of crater-shaped, but with small, flat facets, as evidence of some local action of the current at the point where the arc emanates from the pole. If cooled iron is used as the positive pole, the metal is worn away relatively slowly, disappearing in the form of iron oxide; this disappearance occurs so slowly, however, that automatic regulation of the arc length could be omitted in the forms of lamps based on this principle that have been tried so far. If poles made of less easily oxidized metals, such as silver, are used, the pole is consumed only extremely slowly

The relatively low thermal radiation is related to the fact that crater formation is so greatly reduced. At currents of up to 10-12 amps, one can touch the electrode a few millimeters from the arc without feeling pain, and one can hold one's hand a short distance from the arc for a long time without feeling any pain. At a distance of 5 cm from an 8 amp iron lamp, a blackened thermometer did not rise above 400 in repeated experiments. In an ordinary carbon arc light, the majority of both the luminous and the warming rays emanate from the crater; this light is therefore, in reality, largely an "incandescent light." The light emitted by the cooled metal electrodes, on the other hand, is predominantly true arc light.

because the electrodes only glow on the relatively small areas where the arc emanates from them. As a result, the character of the light is predominantly determined by the respective vapor spectrum of the electrode metal.

Up to now, I have mostly investigated the light from cooled iron electrodes. Since the iron spectrum is so rich in ultraviolet lines, this circumstance determines both the properties of the light and its application. The properties that are of most interest when it comes to using it to treat skin diseases are its skin-irritating and bactericidal ability, as well as how deeply it can penetrate the tissue. As far as the ability of iron light to provoke a light reaction on the skin is concerned, this reaction is extraordinarily great. A few minutes at a distance of 1 m from a 25 amp iron lamp can provoke a light erythema in the facial skin. If the skin of the volar side of the forearm is exposed, for example, If, for example, the patient is exposed to this light for 10 seconds at a distance of 12 cm, an erythema develops, which is characterized as light erythema in that it only appears several hours after treatment and leaves behind pigmentation. The bactericidal properties of the light are proportional to this. While an ordinary carbon arc lamp of 30 amps and 50 volts at the most favorable radiation angle kills Staph. pyog. aur. in a surface culture in 3 to 42 minutes, a corresponding effect is achieved with a 25 amp iron lamp in about 5 seconds (the time is determined by illuminating a suitable section in a rapidly rotating disk).

1) This is referred to as the "relative" killing limit. See the following article

A peculiarity of ultraviolet rays is that they are so strongly absorbed by all substances, and on the whole, the further they are located in the ultraviolet part of the spectrum, the more strongly they absorb them. At wavelengths below 2,200, even water, and indeed air, absorbs them strongly. Glass is only somewhat permeable to that part of the ultraviolet rays which lie closest to the violet part of the spectrum. In agreement with this, it has been shown that an ordinary, approximately 2 mm thick microscope slide completely protects the skin against the effects of iron light, which, without the glass, would have produced a strong reaction with blistering. Ultraviolet rays penetrate the skin even more difficultly. Strebel found that concentrated light could not pass through a human ear compressed between quartz plates In another experiment, a piece of skin, prepared free of fat, was clamped between two quartz plates and "irradiated, excluding all color rays, with concentrated ultraviolet light delivered by induction sparks between zinc and aluminum electrodes." The irradiated object was 140 cm from the spark; a weak but very distinct light appeared on a fluorescent screen placed behind the skin. FREUND1 investigated the absorption conditions in the epidermis by placing pieces of burn blisters, pemphigus blisters, and Thiersch's epidermal strips in front of the 0.2 mm wide slit of a Rowland grating spectroscope. As a light source, he used the spark of a powerful Ruhmkorff inductor with electrodes of Eder's alloy (lead,

1) Archiv für Derm. und Syph. Heft 1, 1901

zinc and cadmium) at a distance of 40 cm from the slit. FREUND came to the same result with regard to all three preparations; he found that beyond the cadmium line, y = 3250 A.E., ultraviolet light, after a 15-minute illumination period, did not penetrate the epidermis pieces in sufficient quantity to be able to act on a photographic plate; as far as the larger wavelengths were concerned, however, a certain amount of light did pass through.

These experiments, interesting in and of themselves, do not provide any quantitative clarification, since, among other things, one would have to know the energy distribution within the spectrum in question; but one can still draw the already probable conclusion that the ultraviolet rays closest to the violet ones penetrate the epidermis relatively better than those further in the ultraviolet range

In order to obtain a preliminary idea of the distribution of the bactericidal rays in the spectrum of iron, I passed the light from a 25 amp iron lamp through a spectral apparatus with lenses and prisms made of quartz. Since the spectrum thus formed lies in a line that forms a very acute angle with the rays emerging from the prism, I renounced examining the spectrum at the point where it was completely pure, but placed a surface culture of B. prodigiosus vertically to the direction of the rays, at a suitable distance behind the prism, where the spectrum was sufficiently differentiated for my purpose. At this point, the spectrum had a visible extent of 10 mm, while the ultraviolet, collected by a uranium glass, had a length of approximately 50 mm. It was now shown that with an illumination of 3-4 minutes, the bacteria in a 6-7 mm

wide strip, the center of which lay approximately 15 mm outside the outermost visible violet band, while no effect was visible in the entire visible band of the spectrum and the next 10 mm of the ultraviolet band. With an illumination time three times as long, the bacteria were killed or weakened over an extension of 40 mm in the ultraviolet spectrum; but even with this illumination, they were not affected in the entire visible spectrum and in the part of the ultraviolet band immediately adjacent to it. The rays that act most strongly on silver chloride paper, as well as those that produce the strongest fluorescence in uranium glass, were distributed in a similar way. Presumably, the agreement between these ratios is due to a corresponding distribution of the amount of energy in the short-wave part of the spectrum, but this can only be determined with the help of bolometric investigations

However, this much is already clear from the experiments: the rays of iron light, which have the strongest effect on bacteria, lie quite far outward in the ultraviolet. This is in good agreement with the fact that the active components of iron light are subject to very strong absorption by the skin. Through a 1 mm thick, fat-free layer of skin (taken from the chest of an approximately twelve-year-old child), the light from a 25 amp iron lamp acts on silver chloride paper three times more slowly than is the case with a 25 amp carbon arc lamp at the same distance and under otherwise identical conditions. It is probably also the visible rays contained in the iron arc light that caused the slight blackening of the paper, which occurred gradually. Through a 0.1 mm thick layer of the same skin on the epidermis side (microtome section of a frozen pre-

parates), on the other hand, the silver paper was exposed to both types of light at the same speed; this thin layer was evidently able to penetrate some of the ultraviolet rays. That they are able to penetrate the epidermis is also evident from the strong vascular dilation they produce.

The characteristics of iron light, as far as we know them so far, are as follows: relatively low heat radiation, strong skin-irritating effect, strong bactericidal effect, very low penetrating power. One possibility for the clinical application of this light is apparently linked to these characteristics. Where a superficial bactericidal and skin-irritating effect is desired, a good field of action must be found; it is not suitable for all deep-seated illnesses, such as lupus vulgaris

For preliminary clinical experiments, I have manufactured a small hand lamp of 8-10 amps and 40 volts. It is intended to be applied in its entirety to the affected area, so that the arc is a few centimeters from the skin. It is equipped with Finsen quartz crystals. The small thimble-shaped iron electrodes must be replaced after the lamp has been burning for 3-4 hours, as they gradually oxidize and disappear as iron oxide smoke. A disadvantage is the occasional precipitation of smoke onto the quartz crystals, which must therefore be dried frequently. With this lamp, one can elicit a typical light reaction with blistering after 3-5 minutes of illumination. Nothing definite can be said at present about the duration of any therapeutic séances; just as little specific indications for their use can be established

A direct comparison between the reactions produced by this small lamp and those resulting from the use of Finsen's apparatus would be misleading; for, since the light from the latter contains a large number of rays that penetrate deeply, the difference in the reactions after the use of the two types of apparatus is not only quantitative but qualitative. The hand lamp should presumably be considered from the point of view that, where an intensive but superficial effect is desired, it achieves such an effect in a considerably cheaper manner than has been possible up to now; where a deep effect is necessary, it should not be used at all.

On the Effects of Light on Microbes. II. An Improved Method of Investigation. By

Sophus

Bang

In an earlier work, 1) I drew attention to the necessity, in investigations into the bactericidal effect of light, of taking into account that the nutrient media in which the bacteria are located during illumination absorb a substantial portion of the applied light. The Buchner method, improved by Finsen, is the most accurate of those used to date. Meanwhile, if the killing time of the bacteria is to be determined precisely, the objection can be raised against this method that it illuminates the bacteria distributed in a layer of agar, namely as a suspended culture. Under these conditions, the bacteria lying in the depths of the agar are not struck by the light until it has been filtered through a more or less thick layer of agar, which, like most other nutrient media, due to its yellowish color and other spectroscopic properties, absorbs short-wave rays to a particularly high degree, precisely those which are most effective against microbes. Small

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1) S. BANG: On the Effects of Light on Microbes I., Reports from Finsen's Medical Light Institute II.

Changes in the thickness of the nutrient substance, its color, and other properties can therefore influence the time the light must act to kill the bacteria. In order to reduce this unpredictable light absorption as much as possible, I used "hanging drops" with a maximum thickness of 0.05–0.15 mm in the aforementioned work. The light absorption of the nutrient medium was not completely eliminated by this, but was nevertheless reduced to a relatively low value, just as a uniform effect of the surrounding air was also made possible. By also taking a number of other physical factors into account, it was possible to achieve reasonably consistent experimental results, which was difficult using the older methods. It was also shown that the bacteria were killed in a much shorter time than one would have expected from the earlier results. This is easily understandable, since the microbes lying in the depths of a light-absorbing agar layer can withstand longer illumination than those closest to the surface

Dr. V. BIE went a step further toward eliminating the light absorption of the nutrient by using "surface cultures" on agar, prepared by spreading a few drops of the bacterial culture in question onto an agar plate poured into a Petri dish. Using a desiccator with calcium chloride and air dilution, the culture fluid dries into a uniform layer. When the surface prepared in this way is now exposed to light, the light does not have to pass through any foreign substances of any significance before it encounters the bodies of the bacteria.

Since this method is somewhat cumbersome

and since such a vigorous drying process is hardly without affecting the vitality of all bacteria, I simplified the method by spreading the bacterial culture as evenly as possible on the agar plate with the help of a fine cotton brush (an iron wire wound with fine hydrophilic cotton, sterilized in a test tube), which was then left to dry spontaneously. My assistant, Dr. Jansen, later used a platinum loop instead of a cotton brush; this partly made it possible to know to some extent how large a quantity of culture had been sown, and partly because the surface dried even faster, after only 2-3 minutes By "drying out" we mean only that there is no free, mobile liquid on the surface; as for the agar itself, it retains its moist consistency and is kept in a moisture-saturated atmosphere during and after the experiment (see below). The possibility that this method may have some influence on the resistance of the bacteria cannot be completely denied, especially when it comes to species that are particularly sensitive to drying out. But as long as no experiment is carried out with such species, and as long as only comparative experiments are carried out with one and the same bacterial species, this circumstance does not come to play any demonstrable role.

That the bacteria really remain on the surface of the agar without penetrating it can be partially convinced when they have later grown to such an extent that the colonies become visible to the naked eye, which in every single case, as far as the bacteria examined so far are concerned, are completely superficial

keep it superficial; in part, with regard to the tubercle bacilli, I was directly convinced by hardening a plate seeded in this way and by making a vertical microtome section through it that the bacilli lay in a thin, flat layer on the surface, without being able to see any bacillus penetrating the surface of the agar layer.

The illumination of the surface culture can be carried out in various ways; the use of stepwise illumination is practical and particularly time-saving This method was used in 1893 by Ward[1], who illuminated the suspended culture in agar through square or circular "windows" that were covered one after the other during illumination. Finsen used a similar method, independently of Ward, in his first experiments on the bactericidal effects of light,2 using, in addition to the method published at that time, the following, which he himself describes as follows: "The plate cultures in a Nielsen flask are exposed to light in such a way that after one minute, a small field of the plate culture is covered with a piece of paper, after 2 minutes a new field, after 3 minutes a third field, and so on. The pieces of paper, glued with fish glue, were black on the side facing the flask to prevent light penetration, and white on the side facing the light to prevent any heating effect. The number was written on the white side to indicate the time.

1) Marshall WARD: Further experiments on the action of light on Bacillus anthracis and on the Bacteria of the Thames. Proc. of the Royal Soc. of London, Vol. LVI, 1894.

2) FINSEN: On the application of concentrated chemical light rays in medicine. 1896, pp. 28-32.

to indicate the time during which the field in question had been exposed to the light. When the bacteria grew and the pieces of paper were removed, a mosaic appeared, caused by the different effects on the various fields, and one could then determine how long the light had taken to kill the bacteria. Later, the method was modified so that the entire bottle was covered with the same type of paper, in which a number of round holes had been cut. After the bottle had been exposed to the light, the holes were then covered one after the other and at specific intervals. This made the effect of the light more pronounced, as each field was now surrounded by a culture completely unaffected by the light, while the surroundings thus simultaneously served as a control. These methods are used with unconcentrated light

I combined the use of step-wise illumination with the use of the aforementioned surface culture by gradually moving a flat "shadow" past the cultures at specific time intervals. Instead of illuminating one preparation for 1 minute and a second preparation for 2 minutes, as is probably usually done, I illuminate a larger area of the surface culture for 1 minute, then move the shadow one step forward, protecting a corresponding strip of the culture from the light. After one minute, I move a new step forward, so that now a total of 2 strips are in the dark, and so on. While the first method of use, to determine the effect of 1-10 minutes of illumination, requires an illumination time of 1 + 2 + 3... + 10 minutes - 50 minutes in addition to the preparations for the individual experiments, the same investigation lasts

The second method takes only 10 minutes in total, and only the preparations required for an experiment are necessary. In addition, it is of course easier to keep the light source constant for 10 minutes instead of 55.

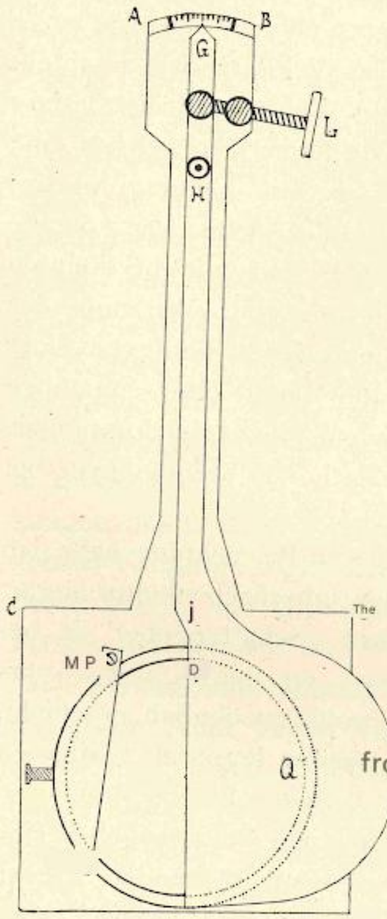

Fig. 9.

following schematic drawing shows the arrangement of the apparatus in which the illumination takes place. The brass plate ABCDEF has a circular cutout MNOQP, which is closed with a plane-parallel quartz disk, behind which the surface culture is placed. The shadow generator OKF consists of a thin brass plate with a long stem FG, which can be rotated around the pin H with the help of the screw L. In this way, the shadow generator is advanced such that its edge OP moves to the right or to the left, with the quartz disk R immediately in front. The amount of advance is read with the help of the pointer Gab. When the shadow generator is advanced as far to the left as it can, the edge OP touches the small plate MN, which constantly shades part of the quartz disk; the corresponding part of the culture thus serves for control. R U NO O E F

Even when the shader is pushed as far as possible to the right, it still shades part of the quartz disk at O, also for control purposes. At U is a tube through which types of air, whose effect is to be investigated, can be introduced into the surface of the culture (a similar tube is located outside Q).

Figure 10 shows a vertical sagittal section through the lowest part of the apparatus. TT is the brass plate on which the entire apparatus is mounted. SS is the shader. At X, the quartz plate is visible. VV is a circular dish in which the agar plate (y) seeded with surface culture rests on a glass plate. At UU, one can see the tubes through which various types of air can possibly be introduced. Culture dish VV is screwed into the apparatus and is provided with a rubber ring (g) to ensure an airtight and watertight seal. The

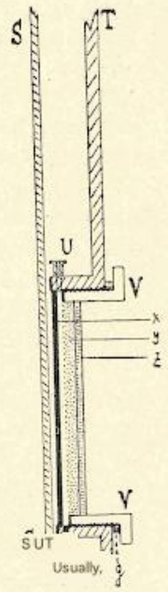

Fig. 10

the entire apparatus is mounted in a "photocteinometer" of the construction explained in my above-cited work. Since I have made a slight modification to it in a special respect, I give a sketch of it in Fig. 11, referring for details to the cited description. The sheet metal box ABCDE is placed in front of a light source in such a way that the light rays strike its surface at a right angle (if it is an ordinary electric arc lamp, it is best to place the container at an angle of 50° with the axis of the carbons). The container is, under ordinary conditions,

filled with boiled, distilled water, which is kept at a constant temperature by means of the water-flowing lead pipes RR and the stirrer P. The shade HHH is placed in the sconces FF. The light penetrates the container through the glass plate MN, passes through the plane-parallel liquid layer between this and HH, and finally reaches the surface culture through the quartz plate X (see also Fig. 10).

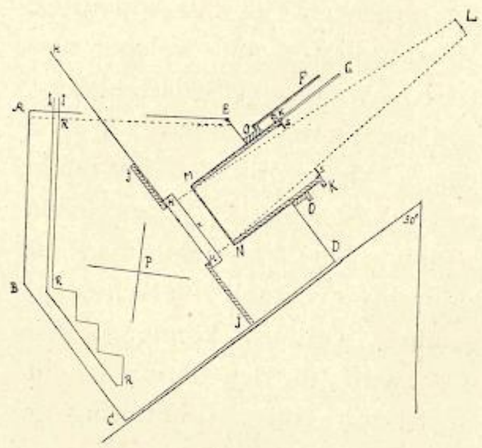

Fig. 11

The only obstacle the light beam encounters on its path from the light source to the bacteria, apart from the air, is the two flat quartz plates and the flat liquid lying between them. In order to be able to vary their thickness in a specific way, the foremost quartz disc, MN, is attached to one end of a tube KNMK, which can be screwed in and out of the ring OO. The thickness of the liquid can be read off the measuring rod F. If necessary, a diaphragm can be used with SS to prevent the light from being reflected from the sides of the tube, which, like everything else inside the container, is matt

black. The lid G is opened and closed to the light.

In order to possibly compare different test results with a common standard, I have provisionally and purely arbitrarily established the following experimental conditions as a "standard experiment."

As a light source, I used a 30-amp, 50-volt electric arc lamp; using switchable incandescent lamps, I regulated the current with an accuracy of 0.1 amp. The positive carbon has a diameter of 24 mm, the negative one 15 mm. (One of the difficulties in reproducing the same luminous intensity using such a lamp is that the nature of the carbon can vary.) By projecting images of the arc in different directions, one ensures that the crater burns with a regular shape. The photocteinometer is positioned so that the rays striking the center of the quartz window form an angle of 50° with the axis of the carbon. The distance between the nearest point on the crater and the surface culture is 60.5 cm, which corresponds to a distance of 60 cm without a water layer, since this is 2 cm thick. 1)

As test bacteria, I have so far used Staphylococcus pyogenes aureus in a 20-hour broth culture, grown at 37°C. They were filtered through ordinary, sterile filter paper and then diluted with 2 parts sterile broth. A suitable amount of the diluted broth, which has a cloudy appearance to the naked eye, was transferred, in the manner described, using a cotton brush or a platinum loop, to the surface of a sterile agar plate, which had preferably been poured into the culture dish a few hours beforehand. As soon as the liquid layer has dried sufficiently, the dish is screwed into the shade-providing apparatus, and this is placed in a "photocteinometer," which should ideally contain a liquid of at least 280, which most reliably prevents fogging of the quartz disks After the gradual illumination has taken place, the removed culture dish is placed in a Petri dish lined with moist filter paper, which is then placed in a thermostat, preferably at approximately 34°C, at which temperature it is easiest to avoid so much condensation that it can drip from the lid of the Petri dish onto the surface culture.

After standing for 24 hours, the culture has an appearance such as Fig. 12, which is reproduced from a photograph.

1) See the cited work, p. 16

On the right and left, one sees two crescent-shaped sections with strong, confluent bacterial growth; these are the unilluminated control sections; between these sections, 10 strips received 1-10 minutes of illumination, respectively. To easily read the position of these stripes, a glass plate, on which the graduations corresponding to the individual stages of the shadow generator are drawn, is held in front of the surface culture. The strip furthest to the left

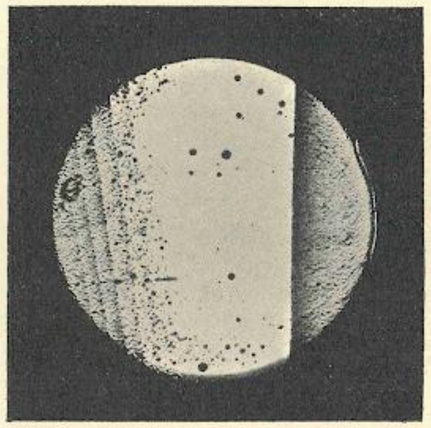

Fig. 12

was exposed to one minute of illumination. A weak light effect is already evident here in that the strip can be distinguished from its surroundings at all; an even somewhat stronger effect is evident in the next strip, which received 2 minutes of illumination. In the third strip (3 minutes of light), one sees a clear reduction, and in the fourth strip (4 minutes of light), the number of colonies is so small that one can count the individual colonies (approx. 50). In the sixth, there are 2 colonies, in the seventh 5, in the eighth 4, in the ninth 4, and the next strip, which was

illuminated for 10 minutes, has only one colony. Thus, after 10 minutes of illumination, we did not yet reach the absolute killing limit (by which I mean the point at which even the most resistant individuals are killed; this, however, can be seen from a second experiment, Fig. 13).

Here, 12 strips are illuminated in such a way that the one furthest to the left was illuminated for 6 minutes, the next for 7, and so on up to the 12th strip, which was illuminated for 17 minutes.

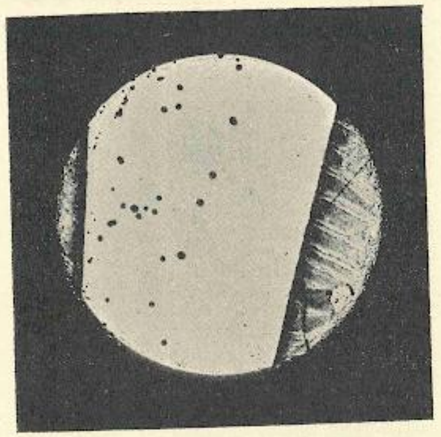

Fig. 13.

The number of colonies in the individual strips is approximately 10, 11, 2, 6, 4, 2, 3, 2, 0, 0, 0, 0. Thus, at the 14th minute, the absolute killing limit seems to have been reached. However, it is only very approximate and with reservations that one can set the absolute killing limit at 14 minutes after such an experiment; because where this limit lies is obviously based, among other things, on the number of bacteria sown per unit area.

An apparently sharper limit can be seen after 4 minutes of illumination (Fig. 12), where the number of colonies has become "countable," while the colonies in the

previous stripes are so numerous that they merge. The position of this limit, which I will call "the relative killing limit" just for the sake of a name, also turns out to depend on how many bacterial individuals are sown on the agar surface per unit area. This can be demonstrated by an experiment with different dilutions of the same culture, as in the following series of experiments:

	Stock culture	Dilution 1:3	Dilution 1:9	Dilution 1:18	Dilution 1:36
Illumination 3 min.	Severe Decimation	Severe decimation	Strong decimation	approx. 50K.	Strong decimation
Beam 3/2	decimation – Strong Decimal	decimation – Strong decimation	decimation approx. 50K	22 K	approx. 50K.
,, 4 ,,	approx. 50 K	approx. 50 K	10	8	5
,, 5 ,,	30	12	1	0	4
,, 6 ,,	16	4	0	2	3
,, 8 ,,	2	4	2	3	0 ,,
,, 10 ,,	2	1	0 ,,	1	0 ,,

Thus, we find no sharp lethality limit for cultures of Staph. pyog. aur. The conditions here are quite similar to those I demonstrated earlier with regard to B. prodigiosus using the drop method, namely, an increasing decimation with increasing light exposure. With these, as well as with a whole series of bacteria examined later, it has consistently been shown, within certain limits, that the longer the exposure to light lasts, the smaller the percentage of bacteria that can resist it. But it seems that this "decimation curve"

has a different distribution and perhaps also a different form in the various bacterial species, as an indication of the different ways in which the unequal resistance of the individuals to light manifests itself in the different species. I shall not go into these conditions in more detail here, since they are currently the subject of special investigations.

At the present opportunity, I would only like to

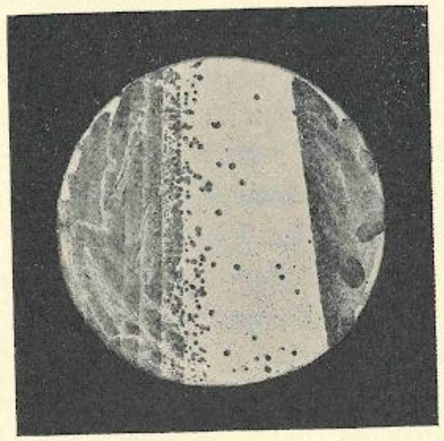

Fig. 14

To illuminate the usefulness of the method for "biological light measurement," that is, for determining the relative relationship between the richness of different light sources in bactericidal rays or the permeability of a light filter for such rays. It has now been shown that the position of the aforementioned "relative killing limit" can be used for many practical investigations of this kind—that is, the point in the culture where the bacterial colonies have become "countable" (approx. 50-100) instead of "uncountable." In 11 experiments with Staph. pyog. aur. on the described

Carried out "normally," the limit was 4.3/2, 4.3, 4.3, 4.3, 4.3, 4.2, 4.2 minutes, on average 3/4 minutes, with a margin of 3/4 minutes or 20% on either side.

This applies when the experiments are carried out at different times; the lack of exact agreement is due to the difficulty of obtaining uniform cultures. Much greater accuracy can be achieved, as I will show in more detail below, by comparative experiments carried out simultaneously or immediately one after the other on one and the same bacterial culture

Meanwhile, the discussed accuracy of 20% is already sufficient for many practical experiments, since it is often sufficient to obtain approximate values, among other things because the different light sources being compared often differ so enormously in luminous intensity. I will give a few examples of this. While a 30-ampere arc lamp at a distance of 60 cm, as mentioned, exhibits an average of 3.5 minutes of "relative killing," the same result is achieved at the same distance in approximately 4 seconds using an arc lamp with the same current intensity, but whose positive pole consists of a water-cooled iron rod. Direct sunlight needed over an hour on August 21, 1901, between 11 a.m. and 2 a.m. (in Copenhagen), to produce the same effect (see Fig. 6, where the position of the shadow generator is changed every quarter of an hour, so that the shortest illumination lasted 1/4 hour, the longest 3 hours).

As an example of the greater accuracy achieved when conducting comparative experiments with one and the same bacterial culture, I can mention that in repeated experiments (6 in total), it was consistently possible to demonstrate the difference in absorption which the light

undergoes when it passes, for example, once through 2 cm of distilled water and the other time through an equally thick layer of ordinary water. While the relative killing limit in this way, when the tube KMNK (Fig. 3) was screwed in so far that the light only had to pass through 1/2 cm of distilled water, was found to be 312 minutes, when the apparatus was filled with ordinary water, it was 5 minutes. If the thickness of the water layer was 3 cm,

	1/2 cm distilled water	1/2 cm wt. water	3 cm distilled water	3 cm wt. water
Exposure 3 min.	Thick decibels	Black decibels.	Black decibels.	Indication of
,, 3 1/2 ,,	approx. 50 K.	Decibels. Black	Decibels.	black decibels.
,, 4 ,,	15 ,,	decibels. Decibels. Black	Decibels	Decibels.
,, 4.2,,	8 ,,	decibels. Decibels.	approx. 50	Black decibels.
,, 5 ,,	7 ,,	approx. 50 K.	K. 28 ,,	Decibels.
,, 5.2,,	0 ,,	30 ,,	10 ,,	approx. 50 K. ?
,, 6 ,,	0,,	20 ,,	3 ,,	

For distilled water, the lethal limit is 4.5 minutes, and for ordinary water, 5.5 minutes

From this, one can see how important the use of the clearest possible water is in the light filters of therapeutic apparatus. And it is therefore no wonder that the light absorption occurring in the commonly used nutrient media reaches a very significant level. To investigate this more closely, I filled the "photocteinometer" with broth instead of distilled water. I used a light-colored veal broth, which corresponds almost exactly in color to a 1/400 solution of bichromate of potassium; through a 2 cm thick

I illuminated a surface culture layer of this broth for 2-24 minutes without obtaining any apparent effect from the light; the experiment was repeated after one part broth was diluted with 24 parts distilled water, again with a completely negative result after 24 minutes of illumination. Only when the broth was diluted with 48 parts water and the thickness of the layer was reduced to 1 cm was the relative killing limit reached after an illumination time of 60 minutes. The layer of diluted broth used would correspond approximately to a 1/2 mm thick layer of undiluted broth. The light used in the experiment therefore needed 1 hour to exert the same bactericidal effect through this layer as it took 3-4.5 minutes to achieve when passing through 2 cm of distilled water. We have here direct proof of the necessity of eliminating the light absorption of the food substrates if one wants to investigate the effect of light on bacteria

Finally, I would like to thank Dr. Jansen for his valuable and tireless help in working out the details of the method.

The Treatment of Smallpox with the Exclusion of the Chemical Rays of Daylight. By Niels R. Finsen.

Two colleagues, District Physician Dr. Krebs in Vordingborg and City Physician Dr. Lunddahl in Aarhus, have, at my request, been kind enough to give me information about some cases of smallpox they have treated in red light, and with permission to publish them, for which I hereby express my sincere thanks. Dr. Krebs has one case, Dr. Lunddahl nine, some of them mild. Although these cases may be of little significance on their own, they are nevertheless important when added to the series of observations already available. Smallpox is, in any case, such a rare disease in this country that one must be grateful for every new observation on the effect of its treatment with the exclusion of the chemical rays of light

District physician Dr. Krebs writes the following:

"On September 4, 1900, I received a smallpox patient for treatment; the smallpox had broken out on the third. Only on the 6th was the patient interned in a Döcker felt tent with red cotton cloth in front of the windows.

The case was of a serious nature, and the exanthema would

would certainly have become confluent, not only on the face, but also on other parts of the body, if the patient had not been treated with red light. (He had 108 smallpox on his right hand alone, and "there are almost none here compared to the rest of his body," the patient said.)

Many nodules had turned into vesicles and partly into pustules when he was exposed to red light, especially on his face. An hour later, the tickling and stinging, the heat and tension in the skin associated with smallpox, began to subside, and by the next day the swelling had considerably diminished. Neither vesicles nor pustules developed further. There was no suppuration, nor was suppurative fever

Instead of the ugly brown and gray spots known from earlier times, a number of vivid pink nodules remained. These could be pressed away with the finger, but immediately filled with blood again as soon as the pressure was released, due to abundant vascularization. A number of pinpoint depressions remained on the face—no true smallpox scar.

For me, who had seen a large number of smallpox cases in the past, the mild course under red light treatment must have come as quite a surprise. The treatment certainly deserves to be consistently carried out in the future wherever the disease should manifest itself, since, in my opinion, it claims great and far-reaching significance.

Mr. City Doctor Lunddahl wrote to me on November 7, 1901: As agreed, I am sending you herewith a brief summary of my smallpox cases, especially with regard to their treatment in red light and its results.

No. 1. 5-year-old girl, vaccinated with good success

in the incubation period. Distributed varicella-like eruption. Only observed later in the course of the disease, since distributed infiltrations with tough, resistant scabs had formed. It took a long time for them to fall off, leaving behind scars that were nevertheless quite superficial. Not treated with red light

No. 2. 7-year-old boy, unvaccinated. Severe initial symptoms. Ill on April 15, 1901. Papular exanthema appeared on April 16-17. Admitted to the hospital on the 17th. Three double layers of red shirting were placed over the windows; this made the room very dark. Daylight was let in for a very short time during the rounds. The exanthema spread and became vesicular; at the same time, the temperature fell, but the general unfavorable condition remained. Suppuration began between the 22nd and 23rd; the temperature rose slightly in the morning (approx. 38°C); in the evening it had been 38 to 38.5°C. Confluence of the exanthema, continuous scab over large areas, with oozing pus. Decomposition with a disgusting stench. On the 24th, the temperature was 40°C. Death on April 26

This case had proven to be a very serious one from its very first onset. Although the patient was placed in the "red room" at the onset of the disease, even with very little light, the disease apparently ran its course unaffected. The only effect may perhaps be that there was no high fever at the beginning of the suppuration stage. It only set in when the pus was decomposing.

No. 3. 4-year-old girl, sister of the preceding patient, vaccinated immediately after the onset of the disease, no effect. Exanthema began weakly on the 18th, quite advanced on the 19th April. On the 19th, in the morning

in the same room as her brother. Her general condition was very poor, but without a high temperature during the first few days. The exanthema spread everywhere, but did not become confluent; between the 23rd and 24th, the contents of the blisters began to turn yellow, and at the same time, a slight rise in temperature was noticed (38.4 in the morning), but the very next day her general condition suddenly improved. On the 25th and 26th, the pustules began to dry together into looser, less coherent crusts, which fell off quite quickly, leaving large, red, round spots, especially on the uncovered skin, which persisted for a long time. A number of fairly small and superficial scars also formed on her face. On May 4, the red light was removed. The exanthema itched only very slightly

No. 4. The children's mother was attacked so easily and with such an insignificant exanthema that it was not worth the effort to treat her with red light.

No. 5. Her newborn, 3-week-old child was taken at the same time as the mother (vaccinated shortly after. Initially, only a Widespread exanthema, very isolated outbreak, no success). isolated vesicles here and there, and apparent well-being. Only after about 8 days of the illness did the vesicles appear on a larger scale, confluent, and finally, almost the entire surface of the body was a suppurating area. The child died on the 28th. When the exanthema broke out more severely, red curtains were hung around the cradle, but during the first few days, when the eruption was very slight, nothing was done in this direction, which probably also proved to be a mistake

No. 6. A 51-year-old washerwoman. Infected by the aforementioned family. Sick since April 25. On

The morning of the 26th, widespread, papular, measles-like exanthema, temperature approx. 41, general condition poor. That same day, in the morning, first taken to a room with red window curtains, later to a room with red panes. That same evening, the temperature was 38.8, and became normal over the next few days. Very few blisters formed on the widespread initial exanthema, but the main mass of the exanthema disappeared without a trace. The general condition improved very quickly. The blisters quickly dried into small, tough scabs, leaving behind some minor infiltrations, and in the palm of the hand, isolated small bleeding spots. Overall, the exanthema of the epidermis decreased a completely abortive course. She remained in the red room which were used for about 13 days. Through the red panes, from then on, significantly more light came into the room; the patients could see, read, work, and generally felt comfortable in this light; there was never a particularly strong desire to escape it. Whether the large amount of light that came in—and it was during the brightest spring months—caused none of the patients, even the most easily affected, to completely escape the scars, which, however, were shallow and will surely be almost invisible later, I cannot say. (The scars only appeared on the exposed skin.) But even if that were the case, perhaps most patients would prefer such a brighter "red room" to a dark one, even at the risk of receiving a few small scars on their faces. I don't believe that the patients would have secretly let daylight in. They were too interested in the treatment and feared harm by violating it.

No. 7. A 7-year-old girl, vaccinated with good success during the incubation period. Ill since May 2nd, eruption on the 3rd, on the 4th a very widespread exanthema with yellow, pus-like contents. Her general condition was very little affected, temperature not above 38°C since admission on May 4th. Drying set in quickly with light, loose crusting and scales. Virtually no itching. She lay in the red light from the 4th to the 18th. Upon discharge in mid-June, large, red spots were seen all over her body. Small scars scattered across her face.

No. 8. 65-year-old woman, not vaccinated since childhood. Ill on May 4th. The following day, a widespread vesicular eruption, which increased in size over the following days, became confluent on the inner thighs, and was very dense overall Also severe mucous membrane eruption. The temperature, which was 39.6 on admission, fell quickly, was already 38 by the next evening, May 5th, and remained low for the next few days, but rose to 38 on the evening of the 8th and the morning of the 9th, as the contents of the vesicles became purulent in the severe and widespread eruption. Drying began early, on the face in the form of tough, dark scabs; on other parts of the body as scales and soft, yellowish crusts, mainly just peeling. The mucous membrane eruption disappeared very suddenly. The general condition was good after the first few days. Lying in red light for a good 14 days. Slight scarring on the face, as in the previous cases.

No. 9. A child died of purpura variolosa one hour after admission

Nos. 10 and 11. Younger women, unvaccinated since childhood, with mild cases of variola discreta; a transitional form to varioloids. Each of them was

observed at home for about 4 days. Treatment with red light from admission onwards for about 10-12 days; the blisters dried into small scabs or disappeared completely, leaving small, red spots. Some of them on the face left scars similar to those described earlier.

No. 12. Younger woman (in her thirties), ill since May 15, papular eruption on the 17, vesicular eruption began on the 18. High fever and severe initial symptoms; the exanthema spread widely. Severe mucous membrane eruption. Admitted on the the first — morning of May 18 General condition was poor for few days (she was also 5 months pregnant), with significant improvement on May 21. At this time, some of the blisters began to develop a yellow content (no particular increase in temperature corresponding to this stage). The course of the eruption was generally as follows: On the forehead, the blisters dried into small crusts; on the rest of the face, the contents were reabsorbed, and papular infiltrations remained. On the body, and especially on the lower extremities, the blisters filled with yellow content, which was also reabsorbed in the meantime. In some places, small, yellowish, loose crusts formed, and in most places only scales. The mucous membrane eruption suddenly disappeared.

— She was in a red room for 14 days. Upon discharge on June 28, her face was densely covered with red spots, and numerous scars formed, especially on her forehead; denser but not deeper, and no larger than in the previous patients

Nos. 13, 14, 15. Two younger women and a small child, all from the country, arrived so late and with such mild cases that red light treatment was dispensed with

With regard to the effect of the red light treatment, one could perhaps say that it had no particular significance for No. 2. The fact that No. 3 progressed well can perhaps be attributed to the treatment. Whether No. 5 would have been saved if the treatment had been carried out from the beginning is doubtful, given her young age. No. 6, in whom the illness began quite violently and took an abortive course, and No. 8, in whom it progressed quite well despite a violent onset and an extraordinarily widespread exanthema, as well as No. 12, who also had a very widespread eruption and whose condition proved quite serious in the first few days, can also be counted among the good results. Whether the red light treatment had any significant significance for the cases Nos. 5, 10, and 11, who were mild from the start, cannot be decided

When I received these case reports, it seemed to me that the results, both in terms of the overall course and in terms of scarring, were less good than they usually are with red light treatment. Since Journal No. 2 mentioned that daylight had been admitted for a short time during the rounds, I suspected that the less favorable results might be due to such a brief admission of daylight. I wrote to City Physician Lunddahl about this and asked for information on this question, as it was of particular interest because nothing definite is known about how much light or how long exposure to daylight is sufficient to cause harm. I also asked about the condition of the patients' smallpox scars after half a year; experience shows that even if patients have small scars upon discharge

after red light treatment, these scars disappear after a short time because they are very superficial

City Doctor Lunddahl was kind enough to examine the patients again immediately, and it turned out that only Patient No. 3 could be described as having pockmarks to a certain degree.

Regarding daylight, I received the following information: "Daylight was let in for all patients during the rounds. For the first two, the curtains were pushed aside slightly; for the others, the windows were left ajar. There was never any mention of prolonged exposure to daylight; a lot can be seen in half a minute, and I don't believe it lasted longer each time. On the other hand, it could have happened a few or more times during the day. Due to the circumstances, there couldn't be a specific round time here, so the patients could be demonstrated at specific times; but the local colleagues could go in whenever they wanted to see the patients. This meant that the patients were possibly exposed to daylight several times, but probably for shorter periods."

This information is of great interest and gives these case reports greater significance, as we seem to have clear confirmation that even very short exposure to daylight has a harmful effect and should be avoided. On the other hand, the use of a stearin light or an ordinary kerosene lamp will not cause any disadvantage to the patient. It may even be possible to leave a stearin light or a kerosene lamp burning all day without harm to the patient, since there are few chemical rays in such light. But the opportunity to experiment with this

Yes, rarely. A series of experiments to investigate and determine which artificial light, and how strong artificial light, smallpox patients can tolerate without experiencing suppuration would be of great importance, partly because some people apparently have an aversion to red light, and partly because the treatment could be carried out anywhere, even where there were no red panes or red window curtains

I would also like to point out here that now that the method has fully passed its test, it is the doctor's first duty—as soon as he has diagnosed smallpox—to ensure that, by one means or another, the windows of the sickroom are tightly closed and that lights are lit. If the treatment can be arranged so easily, it is actually irresponsible to leave the patients exposed to daylight until they can be exposed to red light in the hospital; the better the chance for the patients of escaping suppuration and its consequences.

The Treatment of Rose with Exclusion of the Chemical Rays of Daylight.

By Niels R. Finsen

When I published my treatment of smallpox with the exclusion of chemical rays of light eight years ago, I emphasized that this was "not a special treatment for smallpox, but a new therapeutic principle that could probably become important in other exanthematous diseases and skin diseases." I pointed out how interesting it would be to gain clarity about whether or not chemical rays had any influence on these diseases, and emphasized how easy and at the same time harmless it would be to conduct such experiments, for example, in measles, scarlet fever, and rose. At that time, I made some effort to initiate such experiments, but since I encountered some difficulties and was simultaneously ill and unable to work, nothing came of it. I therefore limited myself partly to some statistical studies to see whether there was a difference in the course of the aforementioned diseases in summer and winter, and partly to suggestions on how to conduct experiments and control trials

Some time later, Corps Physician Dr. Kier, who was then senior physician at the Garrison Hospital, kindly offered me the opportunity to conduct experiments with this treatment in his department. Since several cases of rose disease were discovered at the time, we began with this disease. At my request, Dr. Kier himself undertook the treatment; I only assisted with the installation. In total, only seven cases of rose disease were treated, since Corps Physician Dr. Kier's service was ending at that very moment, and the new senior physician did not attach any importance to continuing the experiments. Since it seemed to me that there were too few and insufficiently developed cases to draw any definite conclusions from them, neither positive nor negative, they were not published

Very recently, a report appeared from Dr. Krukenberg, senior physician at the municipal hospital in Liegnitz, on the treatment of several cases of rose in red light. This has given our seven cases some value as a supplement to those of Dr. Krukenberg. I have now obtained permission from Dr. Kier and the current head of the garrison hospital, Staff Surgeon Dr. Bjerring, to publish them and hereby express my sincere thanks to both of them.

To avoid any misunderstanding, I would like to add that it is not my intention to attempt to deprive Dr. Krukenberg of priority through this publication; but since these seven case reports do not show results as favorable as those achieved by Dr. Krukenberg, I feel there is a special reason, indeed a certain duty, to publish them now

I will first present a review of Dr. Krukenberg's treatise, which is due to Dr. Jansen, and then Dr. Kiers's case reports.

Hermann Krukenberg: Treatment of Erysipelas in the Red Room.

International Journal of Physical Therapy. February 1, 1902.

The author, who is head of the commune hospital in Liegnitz, treated a number of cases of erysipelas in the Red Room during the year 1900, spurred on by an article by Dr. Bie in the "Therapeut. Monatsh.", which gives a comprehensive description of Finsen's entire phototherapy, both "negative" and "positive."

Right at the beginning of the article, Dr. K. expresses his opinion that this treatment has a very beneficial effect on the disease and adds the remark that Dr. Roemer, at the same hospital, has also used the method successfully. But, on the other hand, he himself emphasizes how difficult it is to say anything definite after a single, relatively short series of observations. Especially when it comes to a disease like erysipelas, which can be very capricious in its course and can sometimes be spontaneously cured in a few days, which gives rise to the superstition that the rose can be cured by "incantation."

Dr. K. had the opportunity to apply the treatment to 13 people. If one counts the recurrences as independent cases, one gets a total of 18 cases. There were 15 cases of facial erysipelas of the usual type, 3 of which were located partly on the body and partly on the lower extremities. All patients were placed in a red room shortly after the onset of the disease, and with the exception of the first three, who received some alcohol compresses, no other treatment, either internal or external, was applied. Dr. K. does not appear to have treated other erysipelas patients in the usual way at the same time. It would have been a somewhat safer starting point for evaluating the new treatment than to point out, as Dr. K. did, that the average duration of facial erysipelas can be standardized to at least 1 week; for the erysipelas in Liegnitz could have been particularly benign at that time, where the experiments were conducted. The observations that Dr. K. made during the treatment of these 18 cases in the red room are the following:

The fever usually lasted only two days. It often stopped the day after, or at the latest two days after the patient was taken to a red room. Only in two cases was it different, but in one it was due to pneumonia, in the second, it seemed, to poorly executed exclusion of the harmful rays.

This was otherwise done with a care that cannot be sufficiently praised. A sickroom in the epidemic department had been completely transformed into an excellent photographic darkroom: the window panes were made of ruby glass, the walls and floor were painted red, and lamps like those used by photographers had red glass and coverings. Even the surrounding rooms: corridor, anteroom, closet, and bathroom had red

Window. In this truly "red room," 14 of the cases were treated. Of the remaining 4, 3 were in absolute darkness and also gave good results, while 1, and this was the one I referred to above, was in quite unfavorable conditions, namely in an ordinary room with 4 windows that were covered, but which, according to what Dr. K. later learned, had been open during morning cleaning. In this particular case, the fever persisted for 6 days with a temperature between 39 and 400 degrees Celsius, the illness spread, and the general condition was poor

When discussing the instructions, Dr. K. touches on how often one encounters a complete misunderstanding of the whole matter. There are people who believe that it is a treatment with red light, that one only needs to shine a few red rays of light on the patient's affected areas, similar to how one can give a steam shower. Dr. K. observed the following in a place where he had recommended a red room: The patient lay in his bed in a sea of sunbeams, while at his side stood a burning lamp with a red glass. And this, moreover, was with a doctor.

With regard to the exanthema, Dr. K. comments that the initially sharp borders disappeared within 12 hours, and the progression ceased. However, slight redness and swelling often persisted for several days. Vesicle formation and squamous desquamation of the epidermis did not occur, as was often the case in earlier times. The process often ended with fine desquamation

There were a total of 5 relapses, but none of the relapses occurred while the patient was in the red room. They only occurred after the patient had returned to normal daylight; twice even on the same evening on which the patient was discharged.

The only complications noted were pneumonia in one patient, severe headaches, and fatigue in the patient who was so inadequately treated.

It would have been desirable for the author to have reported how the patients were in the red room. The case is still so new that any information on this matter is valuable

At the end of his article, the author attempts to find a theoretical explanation for the treatment. Would it be possible that Streptococcus erysipelatis thrives better in the light than in the dark? No, this contradicts the numerous experiences regarding the bactericidal effect of light and some experiments conducted by the author himself. (Here at the Light Institute, we also conducted some experiments with streptococci. They showed no particular resistance to light.) Rather, as Finsen said long ago, it must be assumed that it is the skin-irritating ability of light that causes the rash. And just as Finsen expressed his opinion regarding smallpox, Dr. K. also believes that some of the remedies used to date for roses are probably...

only work by excluding light (such as ichthyol, iodine tincture, etc.). In a very interesting way, the author also draws attention to some experiences regarding the pathology of Negroes. According to Daeubler and Plehn, erysipelas and phlegmon are very rare among Negroes, and the fact that this is something peculiar to Negroes and not attributable to the peculiar climatic conditions seems to be evident from a report from the hospital in Dar-es-Salaam (in German East Africa), where both Europeans and Negroes are found. Erysipelas is never observed in the latter, but quite often in the former. Possibly, it is the pigment of Negroes that protects them against the aforementioned disease.

I will reproduce here in extenso the brief case reports that accompany this treatise

F. W., 24-year-old nurse. Last year, she suffered from erysipelas twice, lasting 6 and 5 days respectively.

April 1, 1900. Eczema on the nose, half of the left cheek, and part of the forehead. Evening temperature 39.6.

Red room.

April 2, 1900, morning: 38.5. No spreading. Fever-free in the evening. Redness disappears.

A. S., 15 years old. Had pain for 4 days and her face was somewhat swollen. Admitted.

April 21. Erysipelas almost over the entire face. 38.3.

Epithema, alcohol. Red room.

April 22. 37.2*) 38.3. Erysipelas has reached the hairy part.

April 23. 36.8. Well-being
36.6

3. B. J., 19 years old. Has had redness, pain, and swelling on the right leg for 3 days without any identifiable cause. Admitted April 31st.

Characteristic erysipelas on the right leg with irregular edges; barely extends to the foot, centrally to the knee. 38.0.

1. May 3716. Erysipelas has spread to the foot. 39.3

Red room.

2. May 38.2. No spread. 8315

3. May 3712. 4. May Temp. below 37. The swelling is going down.
3715

4. K. P., 25 years old. Admitted April 20th due to sycosis.

*) Temp. above the line, morning, below the line, evening temperature for the day in question

May 2nd, 400. Erysipelas develops on the left cheek.

Red Room.

May 3rd-6th. Morning temperature approx. 390. Evening temperature approx. 40. Erysipelas extends over the entire face. General condition, poor.

May 7th-8th. Fever falls somewhat.

May 9th. Fever rises. Right-sided pneumonia, bloody sputum, etc. The swelling in the face disappears.

May 12th. Afever-free. Well except for a few stitches in the side.

May 5th. A.M., 54 years old. Mentally ill. Unwell for 3 days: fever, swollen nose. Admitted

May 18th, 390. Erysipelas on the nose and left cheek up to the ear.

Red Room

May 19th, 37.14. May 20th-21st, below 37.0. Swelling decreasing.
38.6

May 22nd, morning: sunlight. Evening 39.0. Recurrence.

Red Room.

23rd, 37.1. May / 36.7.

May 25th, daylight.

6th, P. S., 55 years old. Treated for several months for glandular tuberculosis on the right side of the neck and in the axillae. June 12th, evening temp. 38.5. Unwell.

June 13th. Erysipelas is seen, originating from a fistula and extending over the entire right side of the neck and part of the cheek. Evening temp. 39.16.

Red Room.

June 14th, 38.8, / 39.0 Erysipelas spreading over the right side of the face

June 15th. Fever stops. Still feeling unwell. The swelling only stops completely on June 17th. Daylight.

7th O. W., 15 years old. Said to have had erysipelas a year ago with a fever lasting 8 days. Had erysipelas over almost the entire left side of his face for 2 days, as it was being soaked. October

15th. 38.6

Red Room.

October 6th. 38.2 Erysipelas up to the ear. October 17th.
37 38.0 37.6

The following days below 370. The swelling disappears. October 20th. Sunlight. October 26th, towards evening, fever: 39.1. Recurrence on the left cheek. Redness the size of a palm.

Red Room,

October 27th-28th. Intermittent fever,

October 29th. Fever stops. But a slight swelling persists in the entire face for a few days.

8. M. T., 25 years. Has had redness and pain radiating from the nose and swelling in the face for 8 days. Admitted:

November 5th. Erys. of the entire right side of the face.

Red room.

November 6th, 370. The swelling is going down. November 7th. Fever stopped.
377

9. P. W., 31 years. Was in the eye department because of corneal ulcer. At night between November 29th and 30th, facial pain.

December 1st. Admitted because of rash extending over almost the entire face. 39.90

Red Room.

December 2nd. Evening temp. 39.30. Erysipelas reaches the ear.

December 3rd. 39. Less headache. Redness fades. December 4th. Afebrile.
37.9

Less swelling. December 8th. Sunlight.

October 10th, 15 years (No. 7). November 26th. New erysipelas. Admitted November 27th. Erysipelas already extends over nose, cheeks, lips, eyes, and part of the forehead. 390.

Red Room.

November 28th. 37.12. No progress. November 29th. Afebrile. The swelling
38.2

everywhere considerably reduced. December 1st. Sunlight. Until the 6th/12th, a slight swelling of the left cheek persisted

2nd Th. K., 52 years old. Nurse in a deaf-mute asylum. Got erysipelas on the 6th/10th. Characteristic redness and swelling on the nose and cheek.

39.

7th/10th. Red room with exclusion of sunlight, as best as possible in a room with four windows.
40

Slow progression. Temp. unchanged high..

8th/10th-10th/10th. Same condition. Poor general health. Erys. spreads over the hairy head.

11th/10th. Temp. falls. 12th/10th. Free of fever.

12th A. M., 37 years old. In the asylum for the idiots. 30th/10th. Erysipelatous redness and swelling on the right side of the face, originating from a nasal excoriation. 37.50

Dark room; the staff needs a red lamp when they enter.

October 31. Below 370. The redness disappears.

November 2nd. Consistently no fever. Redness gone. The right side is beginning to peel.

January 13th. J.W., 19 years old. In the idiot asylum. Treated for ozaena in October.

November 14th. Erys. of the nose, cheeks, and the left half of the upper lip. 37.80. Dark room (as No. 12).

Temp. stays below 370. Redness no longer spreads and disappears during the next three days.

December 3rd. Fresh erys. on the left side of the face and inside above the left eyelid.

Dark room.

December 4th. Afebrile, but erys. has spread over a large part of the body. spread.

December 6th. Consistently no fever. Redness disappeared.

December 8th. Sunlight

14th H. M., 51 years old. Operated on April 19, 1900, for recurrence of penile carcinoma. There is still a fistula above the pubis, which secretes slightly.

February 2, 1901. Redness and swelling of the right cheek and the lower eyelid suggest erysipelas. February 3. No fever, but the swelling has spread over the left cheek.

Red Room.

Here, complete freedom from fever. The swelling decreases immediately and has completely disappeared on February 6. The patient is sent back to his department on February 8. The same evening: 38.50. A plate-sized erysipelas originating from a fistula and already on the left thigh.

Red Room.

Immediate cessation of fever, the erysipelas disappears

Excerpt from the journals on the cases of rose treated in red light at the Garrison Hospital by Corps Doctor Dr. Kier:

No. 1. Steenberg's wife. In the hospital from November 18th to November 28th, 1893, for erysipelas faciei and acute nephritis. The illness began 2 days before admission with chills, severe headache, and swelling of the nose. On admission on November 18th, temp. 40.2. Erysipelas all over

left cheek, eyelid, nose, and part of the right cheek. Several blisters.

Epith. boric.
Acetanilidi
Centigr. 25

November 19th (40.3%). Erysipelas now spread on the right side as well as on the
40.2
left. No appetite. Poor sleep due to headache.

Wine, milk, ice compresses.
Syrup morphine hydrochloric. 1 teaspoon.

November 20th (394). Erysipelas has spread further over the
40.4
hairy parts and over the ear. Pulse 108, weak.

Red room

November 21st (40.4). Good sleep without narcotics. Feels
40
somewhat better. Swelling and redness of the cheeks have subsided somewhat, but the affection has spread over the forehead and beyond the hairline. Pulse 120, quite strong. Apnea extremely slight, drinks only wine and milk.

November 22nd, 392. Pulse 93, strong, was less well yesterday,
37.6
but now good towards morning. The erythema has not spread since yesterday, the swelling and redness in the face have subsided considerably, so that the face is almost completely normal today.

September Glacies.

She is beginning to feel like eating.

November 37.5 37. Patient is generally well. She slept well
23rd,
during the night. No headache. The erythema has not spread. Redness and infiltration, even in the hairy parts, are decreasing. Remnants of blisters all over the face. Appearance good.

November 24th, 37. Constantly subjective. Well. Still some
36.8
sensitivity to pressure in the left temporal region.

September

Red Room.

In the following days, albuminuria was diagnosed, which is why the patient was transferred to another department. There was no recurrence

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*) Temp. above the line, temp. of the previous evening, ——
below the line, temp. of the current morning.

No. 2. ANDERSEN*), 23 years old. Admitted on November 28th for erysipelas in association with vulnus contus capitis. Temp. 40.5. Marked erysipelatous redness and swelling of the left cheek and over the left side of the forehead, as well as over the hairy part of the head on the left side.

Red room.

November 29th. 40.4. Slept little at night. Quite severely affected. P. 108, regular and strong. The erysipelas has spread over the entire forehead and lower to the right cheek. Urine normal.

Rp. 1 siphon

November 30th 405. Subjective well-being. Slept well during the night without narcotics. Drinks his milk and wants more. No headache, does not feel particularly weak. The erythema has spread over the entire face. Edema of the eyelids. Abundant vesicle formation on the nose. Pulse strong.

Rp. 4 milk. Sep. 1 siphon.

December 1st 395. The erythema has spread behind the right ear and further into the neck region. Quite significant redness and swelling all over the face, especially on the right side. Reports subjective well-being. Pulse 60. Urine normal. A large bulla on the nose has completely dried up.

December 2nd 39.0 Reports subjective well-being. The erythema has spread to the left parotid region and to the left ear. On the right side, the process has disappeared. Urine normal

December 3rd, 408. Feels quite well, slept well after 38.2

Chloral morphine syrup.
1 teaspoon.

The rash is severe on the left side of the head, especially on the left ear. Wishes to eat more.

December 4th, 38.5 36.5 Well-being. Good sleep during the night after

Morphine syrup, 1 teaspoon.

The rash has disappeared everywhere except in the left ear, where some tenderness and swelling still remains. Urine normal.

December 5th, 370. Still insignificant tenderness and swelling 36.5 in the left ear. Appetite and sleep good. Urine normal.

*) Unless otherwise stated, the patient is a man (commoner).

6/12. 36.9 Still a little swelling on the left ear. 36.5

7/12. 36.7/36.5. Swelling and redness now completely disappeared. Condition good. App. good. Desquamation on the cheeks and ears.

Sep. Milk.

Desquamation all over the face and head.

Sep. Red room. 8/12.

The following days, natural conditions. Discharged 12/12.

No. 3. KUNDSEN, 20 years old. Admitted on 19/12. The illness began about 2 days before. 37.5. The nose is somewhat red, swollen, and sensitive; the same applies to the adjacent parts of the cheeks. Red room.

20/12. 3711 37 Well-being. The erythema has not spread. Urine normal.

December 21st 37.1. 36.6 Complete well-being. Swelling and redness of the nose and the adjacent parts of the cheeks have completely disappeared. Desquamation of these parts.

December 22nd/37. 36.6 Well-being. Nose normal.

extra lectum.

December 23rd Well-being. Nose normal.

Discharged.

No. 4. Kirkegaards, woman, 32 years old. Admission: December 14th. Two days ago, chills and malaise, as well as redness of the nose. Temp. 410. Nose and cheeks show significant erysipelatous redness and swelling. The affection extends over the ears on both sides and up to the eyes. There is no edema of the palpebrae. Distinct, sharp borders. Blistering on the right side of the nose and right cheek.

Rp. Ice.
Red Room.

December 15th 39/40. Patient slept a little during the night after taking a narcotic; Vomited once. Redness and swelling spread up to the forehead. Significant edema of all four palpebrae. Copious blistering on the nose and chin. Pulse quite strong, regular. The urine contained traces of albumen

December 16, 1940. 39.9 Somewhat interrupted sleep during the night. The condition essentially unchanged. The rash has spread somewhat to the hairy parts of the head; but swelling and redness of the face, as well as the edema of the eyelids, have decreased considerably. Some albumin in the urine.

December 17, 1940 39.5. 39 Has somewhat improved after taking morphine juice during the night. Sleep.

The rash spreads over the neck and ears. On the face, however, it has disappeared, and all the blisters there have dried up. Feeling generally better. Desire to eat

December 18th. 38.4 37 Slept well during the night without narcotics. Feeling better today. The rash has not spread. Swelling and redness are still present on both ears and the adjacent parts of the neck. No particular tenderness on the hairy part of the head. The face is heavily scaling. Appetite is good. Traces of albumin are found in the urine.

September Ice, milk, and wine.

December 19th 36.9. 37 Slept well during the night. Overall, feeling well. The rash has disappeared almost everywhere, only some tenderness in the neck.

December 20th 37 36.8 The rash has now disappeared everywhere.

September Red room.

The albuminuria persisted until discharge on December 23rd

No. 5. STEENBERG. Admitted on December 18th. Illness began 1.5 days previously with severe chills. The patient is very weak, sleepy, and dull. Temp. 40. Significant erysipelatous redness of the nose and adjacent parts of the cheeks.

Red room.

December 19th 40.3 40.3. Redness and swelling have spread greatly to the cheeks and forehead. There is edema of all eyelids. Blistering on the cheeks. Slept during the night without the use of hypnotics and is soporous. Pulse regular but weak.

December 20th 39.8. 40. Sleep has been poor during the night. The

The rash has spread across the forehead and to the ears; however, it has disappeared somewhat on the cheeks. General condition, overall poor.

21/12 40.9 40.1. Pulse 108, regular, strong. He reports feeling better. Slept a little during the night after morphine. The rash has spread up to the hairy part of the head in a line corresponding to the coronal suture. Quite severe swelling on the forehead and tenderness therein. The affection has disappeared on the cheeks and nose. The bumps have dried up. Desquamation on the face. Moderate thirst. No appetite. Urine normal.

22/12 40.4. Pulse 96, regular. Slept well after morphine during the night (39.7). Feels overall better. The rash has spread up to the vertex and temple region, but has disappeared on the face

December 23rd, 40.1 39. Condition seems somewhat better. Today swelling and tenderness of the entire neck region and the right ear. The erythema multiforme in the face has disappeared.

December 24th, 40.4 day. Was dazed yesterday during the Wanted to be discharged at 38.5 and get out of bed. Slept well during the night without morphine. Feels quite well towards morning. The erythema multiforme is about unchanged. Begins to feel like eating.

December 25th, 40 during. Feeling better. Was clear yesterday. Slept well the night. 3735. The erythema multiforme has hardly spread, but there is some swelling and tenderness of the left side of the neck and the right ear. The process in the face has considerably disappeared; there is severe desquamation there

December 26th 40.3 40 The erythema appeared again today on the left side of the face. Edema of the palpebrae of the left eye. Sopor. Pulse 86, regular, quite strong.

December 27th 39.8 has Slept well during the night. The erythema not spread, but is starting again on the left side of the nose.

December 28th 391. again Feeling quite well. The erythema is now decreasing

December 29th. 39.6 37.6 Feeling well. Redness, swelling, and tenderness of the left ear are still present. Severe flaking of the face.

December 30, 372. Well-being. Good sleep during the night. 36.8 Only erythema in the left ear, normal urine.

12/31 40.6. Felt unwell last night. Chills. Pain behind the left 37.8 ear. Today the condition is better and the pain has subsided. Nothing objectively abnormal. The erysipelatous process is resolved. Severe desquamation.

September

Red room.

The following days: Discharged in good health 4/1.

No. 6. Hansen, 22 years old. Admitted on December 24th. Illness began approximately two days ago. 37.6. There is erysipelatous redness of the nose and the adjacent parts of the cheeks. No blisters. No clear border to the exanthem.

Red room.

25/12 38.5 15. The rosacea has spread to the left ear. There are now distinct, wall-like borders above the temporal region. 39

26/12. Subjective well-being is good. Slept well. Appetite is good. 40 39.2 The erythema has spread over the right side of the face and beyond the hairline. Urine is normal.

27./12. 3915 37:6 The rose has spread slightly over the left ear Well-being

28./12. 38,3. 37 The rose is very pronounced on the left ear today.

29/12. 37.7. Still redness and swelling of the left ear. Severe sensitivity and swelling of the glands behind the left ear. Subjective well-being,

Rp.
Epithem, tepid.

30./12. 375. The mentioned sensitivity of the glands has 37 disappeared, still redness and swelling of the left ear.

31./12. 36.7/36.6. Complete well-being. Only some redness of the left earlobe.

September

Red room.

The following day continued to feel well. Discharged 6/1.

No. 7. Kirkegaard's wife, 32 years old (see No. 4). Admitted on December 26th. Became ill again immediately after discharge from her previous hospital stay. 39.9. There is some redness and swelling of the nose and adjacent cheeks. Some edema of the lower eyelids of both eyes. A few isolated bumps on the nose.

Red room.

27/12 39.7 37.9

December 28, 376. Slept quite well during the night. Overall, the condition improved. The erythema has not spread. Urine normal.

December 29, 376. Well. No spread of the rose. Face almost 36.9 natural.

30/12 37.6 Well-being. The erythema has subsided somewhat on the face, 37 still some tenderness and swelling in front of and behind the ears. Urine normal.

31/12 37 Well-being 37

Released 9/1

As can be seen, it is not possible to draw any substantiated conclusions from these seven case reports. In cases 1, 2, and 3, where one could assume a favorable effect of the treatment, it is possible that the outcome would have been just as favorable without treatment. On the other hand, the cases where the fever persisted and the disease spread despite treatment are also not conclusive evidence against the value of the therapy; for without this treatment, the outcome would have been

Perhaps it would have been even worse. The capricious nature of this disease makes it impossible to draw a conclusion from it. Since Dr. Krukenberg's good results are available, there is every reason to continue with the experiments, which would best be carried out systematically in a larger hospital, along with control trials. This treatment has the advantage over so many others in that it can be used without hesitation because of its harmlessness.

Literature review.

PAUL DARBOIS: TREATMENT OF VULGUE LUPUS FOLLOWING INDICATIONS. Paris 1900

The author discusses the technique and results of a number of different treatments for lupus vulgaris, a total of approximately 30. Of these, in his opinion, the following are capable of curing the disease: scarification, ignition puncture, galvanocaustic scarification (ignée scarification), surgical methods (excision, scraping), and Finsen's caustic method. Of newer treatment methods, the author considers the following incapable of curing the disease: Koch's tuberculin TR, streptococtoxin, various serums, Holländer's hot-air method, calomel injection, d'Arson-val's currents (high frequency and high intensity currents), electrolysis, and X-rays

It is interesting that d'Arsonval's currents, which achieved good results against lupus erythematosus, had no ameliorating effect on lupus vulgaris

An ideal treatment, says the author, must be easy to apply and painless, as well as produce rapid, definitive healing and beautiful scars. Regarding these individual points, he notes that 1) none of the other methods produce scars as beautiful as those produced by scarification and the Finsens method; 2) definitive healing is possible with all of the methods mentioned, provided that the patients can be kept under observation for at least two years in order to treat any recurrences and remaining lupus foci. The author therefore does not consider it an objection to Finsens' method that patients must undergo one or more short follow-up treatments in the first few years after completion of the main treatment; 3) the quickest treatment is undoubtedly excision, provided that it is achieved prima intentio. The author therefore recommends treatment in cases where the condition is operable and is located in a location where the appearance of the scars

is of secondary importance. In terms of speed, Finsen's method comes second. With all other methods, including scarification, it takes longer to heal than with Finsen's method; 4) the author rightly considers the painlessness of the treatment to be one of the most significant points. None of the other methods can be equated in this respect with Finsen's, which causes no or almost no pain.

From the above, it can be seen that the author considers Finsen's method to be the most perfect. In his "Conclusions," he expressed this view as follows: "Finsen's method is indicated in the majority of cases. However, lupus of the mucous membrane cannot be treated using this method. Furthermore, it cannot be used on rural people and poor people who do not come to the hospital."

"With these reservations, it can be said that, due to the relative speed of its action and the excellent scars it leaves behind, Finsen's method is the best of all the treatments used in lupus therapy."

This recognition of the superiority of Finsen's method takes on increased significance by the fact that the author expressly notes in his introduction that it was Dr. Brocq who first gave me the idea for this work, and it is he who partly inspired the conclusions."

VALDEMAR BIE.

LEREDDE: PHOTOTHERAPY AND ITS APPLICATIONS FOR THE THERAPY OF CUTANEOUS AFFECTIONS. Bulletin Général de thérapeutique. 70th année, vol. 141, p. 129

LEREDDE: LA CURE PHOTOTHÉRAPIQUE DU LUPUS ÉRYTHÉMATEUX. Bulletin de la société de thérapique. 36th year, 4th series, volume VI, no. 1, p. 21. The author gives a detailed report on Finsen's "La Photo-thérapie" and also publishes his own experiences with treatment with concentrated light according to Finsen's method

Regarding the results of the treatment of lupus vulgaris, the author is of the same opinion as Darbois: Finsen's method is the least painful and results in the highest percentage of cured cases, the most reliable definitive cure, and the most beautiful scars. He, too, makes only one objection: the costly nature of the treatment will prevent poor patients who cannot get into a hospital from using it. However, he assumes that the head of public welfare will realize that it is cheaper to ensure the cure of such patients than to place them in poorhouse sooner or later.

Leredde treated a patient with acne rosacea nasi. Significant improvement was achieved, but so slowly that if this were to be the rule

should, Leredde can only recommend light therapy in the few cases of this disease that are refractory to the usual treatments

On the other hand, he was very satisfied with the results of light therapy in a severe case of rhinophyma; the lower part of the nose was twice as large as normal and had transformed into a blood-filled sponge. After 30 séances lasting 1/2 to 1 hour, he achieved a significant reduction in the size of the nose, and the color became bright red.

Furthermore, the author treated two cases of sycosis several years old, which had defied all treatment. In one case, a very marked improvement was achieved after 12 séances

In "La Société de thérapeutique," Léredde published his experiences on the treatment of lupus erythematosus with concentrated light, according to Finsen's method. He treated 11 cases, almost all of which had previously been treated with great perseverance, but without result, using virtually all known methods. The author is particularly interested in the fact that one of the patients, who had previously been treated without result, including in 70 séances with D'Arsonval's currents—in his and Brocq's opinion one of the best treatments for lupus erythematosus—improved significantly after 22 séances of light treatment

In 2 of the 11 patients treated, only slight flattening, reduction of congestion, and atrophy of the epidermis in the treated areas were achieved. The author notes that the treatment was too short (10-12 séances) to allow any definitive judgment. In 3 severe cases, the author achieved partial healing and, as far as the rest of the condition was concerned, significant improvement.

Finally, in 3 cases, complete healing was achieved after 35 and 45 séances, respectively, and 3 other patients, whose treatment is not yet complete, improved so much after 40, 22, and 30 séances that Léredde can predict a complete cure. All in all, Léredde considers that Finsen's method is "the best method for treating severe forms of lupus erythematosus."

VALDEMAR BIE

MALCOLM MORRIS AND S. ERNEST DORE: REMARKS ON FINSENS LIGHT TREATMENT OF LUPUS AND RODENT ULCER. British Medical Journal No. 2093, 9 February 1901, p. 326.

In this article, among other things, there are some valuable remarks regarding the technique of treatment, skin reaction, favorable and unfavorable conditions for treatment, etc.

In all cases of lupus vulgaris treated by the authors, a marked and regular improvement has occurred, although in some cases very slowly

Significant improvement has also been shown in lupus erythematosus, although not as reliably as in lupus vulgaris. A case report is cited which definitely indicates that in the treatment of this disease, the aim is to induce the most severe skin inflammation possible.

The authors' remarks on rodent ulcers are interesting. They believe that light has a significant stimulating effect on the tissue in the base and margins of ulcers, both in lupus vulgaris and rodent ulcers, so that soon after treatment, a rapid ingrowth of the epithelium from the surrounding area occurs. In some cases where the epithelium was not ulcerated, the tumor became red, slightly excoriated, and softer after treatment, and gradually disappeared without loss of substance.

VALDEMAR BIE.

STEPHEN MACKENZIE: ON Phototherapy or the Light Treatment on Lupus Vulgaris. The British Journal of Dermatology Vol. 11, No. 133. Lortet et Genoud (Faculté de Medicine de Lyon. La Boratoire de Parasitologie): La Lumière Agent de Therapeutique. Lyon 1900.

Theodor Schüler: On Light Treatment with Special Consideration of Professor Finsen's Treatment with Concentrated Chemical Light Rays. Monthly Journal for Orthopedic Surgery and Physical Healing Methods. Vol. I, No. 3, 1901.

Henry W. Stelvagon: Phototherapy in Cutaneous Medicine. The University Medical Magazine, December 1900

These four treatises contain reports on the author's visit to Finsen's Light Institute,

VALDEMAR BIE.

MAGNUS MÖLLER (Stockholm): The Influence of Light on the Skin in Healthy and Diseased Conditions,

Bibliotheca Medica, Dept. D. II, Dermatology and Syphilidology, ed. by Prof. NEISSER and E. NÄGELE. Stuttgart 1900. 142 pages.

In this book, illustrated with beautiful photographs and biological plates, the author provides a collected description of the investigations of recent years into the effects of light and X-rays on the skin. Partly, the effect of sunlight and electric light on healthy skin is treated with great thoroughness, and partly the significance of light for summer prurigo, hydroa estivalis, xeroderma pigmentosum, and venereal diseases, as well as the effect of light on pellagra and Finsen's treatment of smallpox

The author also describes some of his own illumination experiments, with the associated histological examinations of great interest. He used the same illumination apparatus with which Widmark, in his time, conducted his fundamental experiments on the skin-irritating ability of ultraviolet rays: a water-filled metal cylinder, one end of which was closed with a rock crystal lens with a 13 cm focal length, the other with a flat glass plate with a cutout in which a flat rock crystal plate was cemented. The rays of an electric arc lamp of 1200-4000 standard candles were made parallel using

the aforementioned rock crystal lens and then passed through the water layer and the glass and rock crystal plate, behind which the author illuminated his own or the test animal's skin. His experiments led to very similar results to those of Widmark and Finsen When using appropriate light intensity and exposure time, light erythema appeared only on the skin areas corresponding to the rock crystal plate, while those exposed to rays that had passed through glass showed no such effect. From this, the author concludes that the effect is due to ultraviolet rays, although, as he himself points out, one cannot conclude that visible rays cannot also exert a similar effect on the skin at higher light intensity. As an effect of ultraviolet rays, the author observed, in addition to the well-known vasodilation, a reduced transparency of the epidermis as a result of proliferative processes. This "clouding" of the epidermis became apparent 2-3 days after exposure; it increases in proportion as the photochemical effect decreases and persists until desquamation ceases. It was particularly evident when the treated skin area, e.g., a rabbit's ear, was illuminated with transmitted light. Histologically, this reduced transparency is due to parenchymatous edema, an abnormally increased epithelial sap content with accompanying hyperplasia, which is particularly evident in the stratum corneum, which becomes more than twice as thick as in the normal state and exhibits an abnormal keratinization process in which the nuclei of the stratum corneum cells are preserved and are abnormally influenced by the pigments. This process, induced by ultraviolet rays, serves, in the author's opinion, to protect the deeper layer, similar to the vascular dilation and the subsequent pigmentation.

The author investigated the deeper effects of light, particularly on the ears of white rabbits, by collecting the light on the inside of the ear with the aid of Widmark's apparatus. With the appropriate light intensity, he achieved not only an inflammation limited to the rock crystal area with blistering on the inside of the ear, but also a corresponding, albeit less severe, affection on the outer side. The author regards this as proof of the not insignificant deep effect of ultraviolet rays. Regarding what we otherwise know about the slight

Knowing the deep penetration ability of ultraviolet rays, it is perhaps doubtful whether the author is correct in this assumption; it may rather be a case of collateral fluxion of significant intensity. The histological examination of the vascular dilation showed, among other things, a strong dilation of the smaller arteries; while their lumen generally shows, on section, a more or less contracted muscularis with strongly folded elastica, the illuminated arteries, on the other hand, showed a thin, unfolded muscularis and an almost smooth elastica, so that they resembled veins rather than arteries. When the strongest illumination was used, thrombus formation occurred in the cutaneous vessels

A series of experiments on guinea pigs and rabbits, intended to investigate whether "sunstroke" could be induced by exposing the animals' heads to strong ultraviolet light, led to negative results, with only nervous phenomena occurring in cases where the heat rays were not carefully excluded.

SOPHUS BANG.

SÖREN HANSEN: On Sunlight in Copenhagen. Some Remarks Regarding the Revision of the Building Code.

Tidsskrift for Sundhetspleje. I R. VII. pp. 65-78.

In this essay, the author wishes to draw attention to the fact that building codes should take the lighting conditions in streets and apartments into account to a much greater degree than is currently the case. Certainly, building regulations are gradually showing a progressive tendency; whereas previously they dealt exclusively with the risk of fire, they now focus more on hygienic conditions However, sufficient consideration of the hygienic importance of light seems to be lacking. Copenhagen is already quite neglected by nature when it comes to sunshine. Of the 4,400 theoretically possible hours of sunshine per year, the sun shines for only 1,200, while Berlin, for example, has 1,727. Of the larger cities, only London (with 1,026 hours) seems to lag behind us. Added to this is the poor quality of a large portion of the sunshine we are granted. One would think that these conditions would require us to construct buildings so that they take as little sunlight as possible from each other; but the author's calculations show that our building regulations, instead of taking advantage of these conditions, actually put us at a disadvantage when it comes to sunshine on facades, compared to cities with which we are almost comparable, such as Berlin. Here, the height of houses may reach 5/4 of the street width, and under certain circumstances even more; in Berlin, the height of houses may not exceed the street width. This means that on a street running from east to west,

With houses 27 cubits high, the northern row of houses in Berlin will have a sunlit area 6 cubits larger in the vertical position during the equinox midday than the corresponding row of houses in Copenhagen. To achieve Berlin's lighting conditions, the southern row of houses in Copenhagen would have to be only 8/9 the width of the street instead of the currently prescribed 5/4. Such requirements cannot, of course, be implemented within the city, but it would be possible for the suburbs, for which the author even proposes the standard ratio of 2/3, which would mean that the southern row of houses could not shade any part of the northern row at the equinox midday. It is to be hoped that the ever-increasing desire for light as a comfort and the growing understanding of the hygienic importance of light will lead the authorities to consider the author's commendable proposal.

SOPHUS BANG

HUGH WALSHAM: On the ultra-violet light from a rapid oscillation high-tension arc, for the treatment of skin diseases. The Lancet. Feb. 1902.

Ultraviolet rays with a wavelength of approximately 200 μμ make the air they pass through conductive for electricity. The author used this property to investigate the penetrating power of these rays. He used an alternating current lamp (not described in detail) as his light source. When the light from this lamp was directed against an electroscope charged with negative electricity, its gold leaves collapsed, and the author used the speed with which this process took place as a measure of the quantity of the rays mentioned. By inserting various bodies between the lamp and the electroscope, he determined their absorption ratio According to his experiments, two 2 mm thick quartz plates spaced 10 mm apart should absorb 60% of the rays acting on — the electroscope. If the space between the plates is filled with water (distilled? boiled?), 10-15% of the remaining rays are absorbed. A gelatin plate 0.04 mm thick blocked all — rays, while a 6-inch thick block of ice absorbed barely more than the corresponding column of air.

This ratio prompted the author to use small inch-thick pieces of ice as compressors instead of Finsen's pressure glass in the light treatment of lupus. The author assumes that the cooling effect of the ice will also contribute to the completion of local ischemia. The fact that the author was — able to use this technique at all is only to explain that he used a weak light source without concentrating the rays to treat lupus, and that the sessions only involved communications from Finsen's

10-15 minutes. — Experiments at Finsen's Light Institute have shown the inadequacy of such methods, and in addition, rays with such great refractile properties are absorbed in the uppermost layer of the skin. The author admits this — by emphasizing that the penetrating power of light rays decreases with their wavelength, but he tries to circumvent the matter with a few words by saying that the wavelength is so easy to lengthen or shorten, even when the rays strike different bodies, that it would not be wise to dogmatize on this point!

—

It is clear that such an application of ice as a compressive agent must also be very unpleasant for the patient; the author also does not mention this downside.

GUNNI BUSCK.

G. J. MÜLLER: Actinotherapy. — Medical Calendar of the General Medical Center tralzeitung. 1902. Berlin

Under the name "Actinotherapy," the author summarizes the four modern physical treatment methods below, of which he gives a clear and concise description.

Applications of 1) the concentrated chemical rays of the arc lamp or sunlight according to Prof. Finsen's method,
2) X-rays,
3) the ultraviolet rays of the induction spark according to Strebel's method,
4) Becquerel rays.

In his discussion of concentrated chemical rays, the author essentially follows the views put forward by Prof. Finsen and his students; only, purely theoretically, he places greater emphasis on the inflammatory — properties of the rays than on their bactericidal power.

The author recommends X-rays for for the treatment of. He finds hypertrichosis, sycosis parasitaria, and favus, in — them contraindicated all acute, inflammatory dermatoses, especially —

Strebel's apparatus for utilizing the ultraviolet rays of the induction spark and Becquerel rays (chemically active rays emitted by uranium and thorium) are only mentioned by the author.

GUNNI BUSCK.

Dr. ENGEL (Cairo): On the treatment of smallpox with red light, along with some remarks on forced vaccination.

"Therapy of the Present", March 1901.

During an epidemic that occurred in Egypt in the spring of 1900, a total of 177 smallpox patients were admitted to the Infectious Disease Hospital in Cairo. Of these, 25 were treated according to Finsen's method.

As a result of a well-conducted mass vaccination (in April alone, over 278,000 inhabitants of Cairo were vaccinated or revaccinated), the epidemic ceased shortly after the treatment was initiated

The author publishes his results in the above-mentioned treatise, expressing the hope of thereby contributing to the "publication" of a method which, in the author's opinion, has not yet received the attention and widespread use it deserves.

The author describes the tremendous change that occurred in the sick rooms after the exclusion of chemical rays: the penetrating stench, which had been almost unbearable due to the accumulation of so many suppurating patients, disappeared completely, and with it the numerous flies that had previously been a constant plague for the patients.

The author was unable to observe any harmful effects of exposure to filtered light on the patients or the staff, but he emphasizes that the patients became restless and could only be kept there with difficulty until the vesicles had completely dried out, precisely because subjective well-being — occurred so early

Although the skin eruptions always took on an abortive, benign character without suppuration, the author found that the treatment had no effect on the exanthema localized on the mucous membranes (pharynx, larynx, conjunctiva), and he believes this is the reason for the contradictory results of the various observers regarding the incidence of suppuration fever under Finsen treatment. It is clear from the reported case reports that the affection of the mucous membranes is, on the whole, of great prognostic significance—something to which previous authors (e.g., Curschmann) — have also drawn attention

If, according — to the author, one disregards the fulminating cases of purpura variolosa and variola hemorrhagica, as well as cases where the mucous membranes are primarily severely affected, the disease will progress like variola, and the cosmetic result will be satisfactory from the moment — the patient is treated according to Finsen's method.

The author calls this the first rational and methodical treatment of variola; he believes that it should be introduced everywhere as an obligatory part of smallpox treatment and that permanent facilities for such treatment should be established in all states where smallpox cases occur constantly or only frequently.

As one can see, the author unconditionally and zealously supports the proponents of the . — method. This makes his view of

the influence of treatment on mortality. The author does not believe that it will bring about any reduction in the mortality rate, although he also admits that it can have a certain influence on this by preventing mixed infections and complications in the later stages of the disease, which may be of particular importance for old and weak patients.

One should certainly be careful with numbers; but one can also be so careful that the conclusions are misinterpreted. When you go through the author's statistics, it also becomes clear that he was clear-sighted! — very pre-

The smallpox patients, few of whom had been vaccinated and none of whom had been revaccinated, were interned in two pavilions — A and B. The milder cases were placed in A, the more severe cases in B, and this separation between mild and severe cases was continued in the same way after Finsen treatment was introduced in Pavilion B on May 8th. The probability rate was before — May 8th in Pav. A: 17% (6 out of 35). 45% (9 out of 20). — After May 8th in Pav. A: 20% (1 in 5) died. Die-In Pav. B: — In Pav. B also 20% (5 of 25). Of these 5 patients who died despite the treatment in red light, one was a child who was only brought in at the suppuration stage and thus came under treatment too late, since the importance of the method is that it prevents suppuration. The four others had what the author just highlighted, in addition to a confluent skin rash, an — intense and severe affection of the mucous membranes in the throat and in the trachea. The author draws his conclusions from these numbers!

In various monographs on variola, Referent tried to find statistical information about which days of illness deaths occur most frequently. It goes without saying that Finsen treatment, which only aims to prevent suppuration, cannot have any influence on mortality in the first few days of illness. On the other hand, it is equally clear that the mortality attributable to — cutaneous suppuration and the complications dependent on it is reduced to o, the moment the suppuration is prevented. It

Most authors state that purpura variolosa almost always causes death in the first few days of illness. Apart from these foudroyant cases, the greatest mortality occurs during or after the suppuration period.

Since the author now considers it to be clinically established that by excluding the rays of light that cause inflammation from the patient, they are protected from cutaneous suppuration and its consequences, he must logically conclude that such treatment reduces the mortality rate for variola.

Finally, the author mentions forced vaccination. He believes in the possibility of a beneficial influence on the secondary period,

and thinks that they hardly pose any danger to the patients. and should therefore be tried wherever Finsen's method is not feasible.

GUNNI BUSCK.

DEGRAIS: The rayons chimiques et de leur emploi dans la thérapeutique des affections cutanées. (Traitement du Lupus par l'appareil Finsen.) Thèse. Paris. 1901.

The author has familiarized himself quite thoroughly with the literature that has appeared in recent years on chemical light rays. Magnus Möller and Finsen appear to be his main sources. Without engaging in any kind of criticism, he guides the reader through the entire physiology of light in just a few pages: the influence of light on metabolism, light erythema, pigmentation, excitation and permeability.

After the general part comes a description of phototherapy. Finsen's concentration apparatus for sun and electric light is described in detail. He also describes Lortet et Genouds and Faveau de Cour-melles et Trouvés apparatus, as well as an acetylene lamp given by Callevilles. The author speaks about the latter with great caution. So far we only know the value of the Finsen installation, and the results which the author presents can all be traced back to it, as found in the Saint Louis Hospital (Dr. Balzer's Service). He has a total of 16 medical reports: 13 lupus vulgaris, some cured, some improving. In 3 cases the fin treatment was combined with scarification (Leredde's suggestion), and the author is very satisfied with this. The scarifications were carried out under cocaine anesthesia immediately before the light treatment. The remaining 3 were Lup. erythematous. They proved to be refractory.

Finally, the advantages and disadvantages of fin treatment are compared and the indications for the same are presented, all in essential accordance with Dubois' dissertation (which can be found referenced in this issue).

HANS JANSEN.

BAYLE: Contribution to the study of phototherapy. (Finsen method.)

Thesis. Lyons. 1901.

This dissertation is under Prof. Lortet and Dr. Genoud's aegis appeared and therefore concludes with the thesis that her lamp can replace Finsen's. The work is extremely thorough in its entirety and is divided into three sections. The first gives an overview of what was known about the effects of light before Finsen, and particularly highlights the French

contribution stands out strongly; the second is devoted exclusively to Finsen's work, and the third deals with Lortet and Genoud's lamp.

With regard to the last section, I can refer to Lortet and Genoud's original treatises, since there is nothing particularly new in Bayle.

HANS JANSEN.

1901. FOVEAU DE COURMELLES: La Finsenthérapie. — Le Médicin. 4 avoût

FOVEAU DE COURMELLES: La Photothérapie. — Le Progrès medical. 2 November 1901.

The articles mentioned are two of the many that the author published in the last six months In all of these, the author moves in a most peculiar way between lyrical outbursts of emotion and strict scientific rigor, summarizing in a blanket manner everything that has been published in the field of light therapy without making any distinctions. The final refrain is always that the only excellent device is an apparatus he himself constructed, which is described and illustrated, but in such a convoluted manner that it has been impossible for the reviewer to form any clear idea. The light source can be either an incandescent lamp with special carbon (lampe à incandescense à charbon spécial), the composition of which has not yet been published, or an ordinary arc lamp. In both cases, only 5-8 amps are necessary; finally, the use of an acetylene lamp is also possible. This light source is mounted in a metal envelope, the rear of which is a parabolic mirror, the front of which is a screen with a quartz disk. The casing consists everywhere of double walls through which water flows. The light source is mounted at the focus of the mirror, whereby all light is emitted at the front as parallel rays. There seems to be no concentration. Only the rays that strike the disk reach the patient. A more detailed criticism of such a weakly defined lamp is impossible; it should only be emphasized that the use of mirrors was attempted here a long time ago, but was abandoned because they are very quickly attacked and ruined, at least when using an arc lamp.

HANS JANSEN

LORTET & GENOUD: Non-condensing phototherapy device. Compt. rend. des séances de l'Acad. des Sciences t. CXXXII p. 527 (March 4, 1901).

LORTET & GENOUD: Non-condensing phototherapy device for the application of Finsen's method,

Lyon Médical (March 17, 1901).

Notice on the non-condensing phototherapy device by Lortet & Genoud,

Professor Lortet, doyen of the medical faculty in Lyon, who was one of the first to introduce Finsen's phototherapy in France, did not limit himself to this. In collaboration with Dr. Genoud, he attempted to devise an improved arrangement for the therapeutic application of arc light, and it is this "lamp" that is presented to the public in these treatises. Although it is hardly as excellent as the authors seem to suppose, there is nevertheless much good in their endeavors, and since the lamp became widely used in France, it contributed greatly to paving the way for phototherapy.

Lortet and Genoud set themselves the goal of 1) avoiding the concentrating apparatus, since it absorbs part of the light, and 2) adapting the lamp for individual treatment so that every general practitioner could have one in his or her office They therefore require an electric projection lamp (a conventional arc lamp with tilted carbon), which emits its light primarily to one side, and place the affected area at a short distance from the arc. This is achieved by inserting a metal screen with double walls, through which cold water flows, between the patient and the light source. This metal screen has a 2.5 cm circular opening just in front of the arc, which is closed with a Finsen water-permeable pressure glass. If the patient is pressed firmly against it, any heating effect is supposedly eliminated. The lamp must be regulated by hand and can be adjusted in every conceivable way using numerous screws. It should burn at 12-15 amps, 55-65 volts, the arc should be at a distance of 2-4 cm from the pressure glass, and the duration of the séances should be only 5-15 minutes (in earlier treatises, 8-10 amps, 1-2 cm distance, and 15-20 minutes are stated).

Quite apart from the fact that it is impractical to position the patient in this way and to regulate the lamp by hand, it is a priori unlikely that this lamp can achieve the same effect as the Finsen installation. It is certainly impossible to investigate the relationship between these two devices by calculation; for, on the one hand, it is not easy to determine how much Lortet gains through the projection position, and, on the other hand, it is not possible to calculate how much Finsen loses through the concentration apparatus. We can only draw attention to the following: 1) Lortet does not fully benefit from the projection position The crater will be slightly positioned to the side of the carbon, but will not be completely vertical, and the rays will therefore not be projected horizontally to the side, but rather a large portion will fall outside or below, thus hitting the printing glass at an unfavorable angle or not at all. 2) The patient is not particularly close to the light source. In addition to the 2-4 cm between the sheet and the printing glass, the latter represents another 2 cm, so the treatment distance is 4-6 cm. With Finsen's treatment distance

One must calculate the distance from the arc to the front lens of the concentrating apparatus; here, the rays are made parallel, and thus they retain their intensity throughout their further travel. This distance is 12 cm for an ordinary 7 cm apparatus. Lortet thus takes the light from a location where it is 4-9 times stronger than where Finsen takes it. But whether this slight advantage, in conjunction to outweigh — with the projection position, should be able — Finsen's concentration, with which the light is amplified about 30 times according to calculations, as well as its 5 times greater power consumption and, finally, its 4-5 times longer treatment time, is unlikely. Firstly,

The question can only be resolved through exact comparative experiments; Lortet & Genoud do not cite a single one of these. They conclude exclusively from "reactional and curative effects." Exanthema and blistering occur, just as with Finsen treatment; but the authors may not be aware that the Finsen apparatus can achieve exactly the same thing in an even shorter time. The maximum reaction is reached quite quickly, often after just a few minutes, and increasing the illumination time or the light intensity does not significantly change its appearance, although it can be assumed that the depth of effect is all the greater. Finsen was therefore right never to be satisfied with the time and light intensity precisely necessary for maximum effect, but went much further and can probably achieve a greater depth of effect precisely for this reason

It should now only be added that we conducted a series of experiments with Lortet lamps at the local Light Institute, which will be published later, and the main result is that this lamp, in terms of bactericidal power and depth of action, is 3-4 times weaker than a Finsen installation with a 70 amp arc lamp and a 7 cm concentration apparatus and thus represents a significant step backward.

HANS JANSEN.

STREBEL: A LIGHT THERAPY QUESTION. Wiener Klin. Rundschau No. 50-51, 1900,

Strebel: A Contribution to the Question of Light Therapy Instruments. Meeting of the German Dermatological Society. Breslau 1901. Strebel: The Usefulness of Induction Spark Light in Therapy. Lecture. The 73rd Meeting of German Natural Scientists and Physicians. Hamburg 1901.

In recent years, Dr. Strebel in Munich has occupied himself with phototherapy with great zeal, particularly with its physical side, and has demonstrated considerable expertise in this field, although, on average, he has also been very critical, even if, as the speaker believes, he is inclined to put forward hypotheses that are not entirely well-founded.

In the first treatise, the author rightly rejects the widely used light boxes, regardless of whether they are equipped with arc lamps or incandescent lamps. They achieve little photochemically, and harmful gases are collected in them. Instead, he suggests having the patient lie in powerful projection arc lamps with mirror reflectors. He considers inserting colored glass plates pointless. While the author here generally campaigns against the strong charlatanism that is practiced with the use of various lights, he touches on the treatment of smallpox and shows a remarkable lack of understanding by saying that he cannot see why red light should be used; darkness must achieve exactly the same thing.

In the second, the author deals with the important and modern question of the value of ultraviolet rays. He points out their significant absorption through a series of experiments; he finds that a 1-mm horn plate absorbs most of them, just like glass Possibly, they could penetrate better in concentrated form. He tests this by using a quartz lens, which collects ultraviolet rays differentiated by a prism, to project the light cone against a piece of skin and hold a fluorescent screen behind it. While no fluorescence was visible after penetrating a compressed rabbit's ear, visible fluorescence appeared after passing through freshly removed human skin. Apart from this experiment, which one would have liked to repeat and vary, he concludes that the outer ultraviolet rays have only little value when it comes to penetrating the skin. Finally, the author suggests replacing lens concentration with mirrors. A new mirror metal, Magnalia, has been invented, which is supposed to be more resistant to the ozone effect of arc light. Using several drawings, he shows how he envisions the installation in such a case. In the same lecture, but without any connection to the rest, the author presents his "spark light" on the main topic.

of the third treatise. The principle of this Strebel lamp is to allow strong induction sparks to arc between electrodes made of aluminum, calcium, or zinc. This produces a very strong, yet only slightly luminous light with ultraviolet rays. It is almost completely cold, so that it can be introduced into the body cavities, and here the author also wants to seek an area for "ultraviolet therapy," as he believes that the mucous membranes are more penetrable than the skin. Finally, he presents some therapeutic results achieved with this light, including two cases of gon. fluor. albus and two cases of urethritis in men.

Hans Jansen

Printed by August Pries in Leipzig

Published by F. C. W. Vogel in Leipzig.

On the Significance

of Chemical Rays of Light for Medicine and Biology.

Three treatises by Prof. Dr. Niels R. Finsen in Copenhagen. With 6 illustrations and 6 plates, size 8. 1899.

Price: M. 2.50.

On the Application of Concentrated Chemical

Light Rays in Medicine

by

Prof. Dr. Niels R. Finsen in Copenhagen. With 4 illustrations and 2 plates. size 80. 1899. Price: M. 1.20.

Communications from Finsen's Medicinske Lysinstitut (Finsen's Medical Light Institute) in Copenhagen.

I. II. Edited by Prof. Dr. Niels R. Finsen

The German edition edited by Dr. Valdemar laboratory assistant at the institute. 1900, 1901, price 3 marks each.

Bie.

Printed by August Pries in Leipzig.

FINSEN, MEDICAL LIGHT INSTITUTE. II. HEET.

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COMMUNICATIONS FROM

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MEDICINSKE LYSINSTITUT

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(FINSEN'S MEDICAL LIGHT INSTITUTE) IN COPENHAGEN

III

EDITED BY PROF. DR. NIELS R. FINSEN

THE GERMAN EDITION EDITED

BY DR. VALDEMAR BIE, LABORATORY ASSISTANT AT THE INSTITUTE

LEIPZIG

PUBLISHED BY F. C. W. VOGEL 1903

NOTICES

FROM

FINSENS MEDICAL LIGHTING INSTITUTE

BY

NIELS R. FINSEN

IV

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ANNOUNCEMENTS

FROM

THE FINSEN MEDICAL LIGHT INSTITUTE

BY

NIELS R. FINSEN

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MEDDELELSER

FRA FINSENS MEDICAL INSTITUTE

IV

NOTICES

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NIELS R. FINSEN

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ON THE USE IN MEDICINE OF CONCENTRATED CHEMICAL LIGHT BEAMS.

CONTINUED MESSAGES

OF

NIELS R. FINSEN.

Since I published my treatise in December 1896: "On the Use in Medicine of Concentrated Chemical Light Rays", which was accompanied by a "Preliminary Notice on the Use of the Method in Lupus Vulgaris", conditions have changed quite considerably. While I had then used the method for only one year and in only 11 cases of Lupus Vulgaris, it has now been used for 6 years and in over 800 cases of Lupus Vulgaris, in addition to many cases of other disorders. What was then an interesting experiment that promised much has now proven to be more than that, and the method has not only kept what it promised, but has also in several directions far exceeded my expectations.

The first and most important of the investigations which form the basis of the method and on which it is built have been published in the above-mentioned treatise; but my later investigations, which have had the purpose of improving and deepening the method, I have not yet published.

In the various, quite numerous reports on this treatment method that have been published in the past from the

The institute (see the list in "Reports from the Finsen Medical Light Institute" I. P. 4) has mainly concerned the results of the treatment, to which have also been attached reports on the most important changes and improvements that the treatment devices have undergone. On the other hand, almost nothing has been reported about why these changes were made. It is these underlying investigations that I will report here. I will also give a comprehensive description of the method and the position it currently holds in both technical and therapeutic terms.

These investigations, which for the most part now date back 4-5 years [1]), are essentially of a physical nature; they are quite naturally characterized by the fact that they were undertaken exclusively with special and practical purposes in mind, and by being carried out by a non-physicist. Despite the shortcomings resulting from this, I will nevertheless publish them, since there is a certain need for it. The method and my apparatus are already being used in numerous places abroad, and I therefore owe information about why the apparatus and method are exactly as they are, why, for example, one should use lenses made of glass for sunlight and of quartz for electric light, why one should use clear distilled water for electric light-collecting apparatus and bluish-colored water for solar-collecting apparatus. These and several other conditions seem to be in conflict with each other and need further explanation. If I do not provide the explanation and the underlying experiments, I may risk that the apparatus and technique will be changed in the wrong direction, to the detriment of the method.

First, however, I must make the observation that one might

1) In carrying out these studies, I have had a lot of help and support from my two assistants at the time, Doctors Valdemar Bie and Axel Reyn, to whom I hereby extend my best thanks.

will consider some of my investigations to be superfluous, because the conditions are considered to be already known. To this I can only reply that when it turned out that various physical indications which I had found on my subject (concerning the absorption of rays, etc.) did not fit with my experiences, and when the light intensity which was involved in my experiments so far exceeded the light intensities generally used in experiments, I thought it best to take up almost all questions pertaining to this for renewed investigation.

The nature of these investigations naturally follows from the principles underlying the method, and these are, as is well known, an application of 1) the bactericidal and 2) the inflammatory properties of light, as well as 3) its ability to penetrate human tissues.

In order to be used in practice with any effect, however, the light must be strongly concentrated, and at the same time, in order to prevent combustion, the strong heat caused by the concentrated light must be removed.

The questions that therefore needed answering were the following: 1) Which rays in the spectrum are the most bactericidal. 2) To which rays is the inflammatory effect due. 3) How can one get rid of the annoying heat rays most easily and best, without at the same time losing the beneficial bactericidal and inflammatory rays? 4) What is the situation with the passage of light through the tissues? Furthermore, other questions arose that also concerned light, and which were partly dependent on the answer to the preceding ones, namely: 1) What can be done to obtain artificial light that is rich in rays with the desired properties and poor in heat rays? 2) Which parts of the electric arc light are the best, the light that emanates from the coals, or the light that emanates from the arc? 3) How does sunlight differ from electric light, and what 1*

Does this difference have significance for the construction of solar devices and for the treatment of diseases?

This is followed by another series of studies on the best way to concentrate the light, so that one gets as much as possible out of the good properties and avoids as much as possible the disadvantage of the heat rays.

I will, as far as possible, address each question individually and either provide an answer to them or point you to where you can find answers.

1. Which rays in the spectrum are the most germ-killing?

To this I could already reply in my above-mentioned first treatise, p. 13, that according to numerous investigations which I also found confirmed by my own experiments, the most refractible, the blue-violet rays, must be considered the most strongly bactericidal, while there was some divergence concerning the most refractible, the ultraviolet. By more extensive investigations which were later carried out at the Light Institute by Dr. V. BIE [1]) on this extremely important point, and to which I refer, much more clarity has become available as to what an exceptionally large part of the bactericidal power of light belongs to the most refractible rays, and what an insignificantly small part the less refractible rays (the red and yellow) possess. Dr. BIE'S investigations were carried out with collecting apparatuses, provided with glass lenses, and his results are of the greatest importance for all rays which could pass through glass; but a large part of the ultraviolet rays are absorbed by glass, as is well known,

1) V. BIE: Studies on the Effect of the Different Parts of the Spectrum on the Development of Bacteria. "Reports from Finsen's Medical Light-Institute I. P. 33.

while they pass through rock crystal. It was now of great importance for the method to know how much significance these ultraviolet rays absorbed by — glass had as germicidal agents; — on this would depend whether rock crystal lenses should possibly be used for the light-collecting apparatus instead of glass lenses as hitherto.

I therefore conducted (May 22, 1897 at 101 pm) experiments in this direction, which I refer to in my Experiment Book.

The light from an 80 Amp. lamp was collected by means of a small collecting apparatus, consisting of a metal tube 6 cm. long, one end of which was closed with a rock crystal plate 6 cm. in diameter, and the other end of which was closed with a rock crystal lens 51/2 cm. in diameter and 6 cm. in focal length, between which was distilled water. By means of this apparatus the light was collected on a spot 6 mm. in diameter on a plate culture of Prodigiosus, in the same way as we are accustomed to use them at the Light Institute, only in this experiment I let the light fall directly on the culture, that is, on the surface facing away from the glass. I made 3 experiments, each lasting 5 minutes. In the first experiment a rock crystal plate was placed between the collecting apparatus and the culture, in the second experiment a glass plate of ordinary window glass, in the third experiment a somewhat thicker plate of clear mirror glass. On inspection the next day at 11/2, a weakening of the growth of the culture was seen on all 3 spots. On the two spots where the light had passed through the glass plates, the growth was weakened approximately equally, but very slightly; on the other hand, much stronger where the light had passed through the rock crystal plate (the three spots were placed side by side on the same plate culture). On inspection the following day (the 24th) at 31/2, the rock crystal spot was seen clearly and distinctly, here the majority of the bacteria had been killed, only a very few colonies had grown. On the two glass spots, however, the growth was now just as good as on the unlit parts, pigmented everywhere, only a little darker in color than on the

the unilluminated part. This result, which I have found confirmed by later similar experiments, shows an extraordinary preponderance of bactericidal power in the extreme ultraviolet rays. A necessary consequence of this experiment was the introduction of rock crystal lenses instead of glass for the treatment apparatus, and as can be understood, an extraordinary amount has been gained by this. I cannot, however, state exactly how much has been gained by this change in figures, but you will get an impression of it when I mention a few figures. Dr. BIE found in his investigations that concentrated light from a 35 ampere lamp, concentrated by a glass collecting apparatus, killed a Prodigiosus culture after 35 minutes of exposure. With a rock crystal collecting apparatus (with 7 cm. lenses) and a lamp of the same size I have been able to kill a culture of the same bacteria in 2-3 seconds [1]).

To investigate how the situation was with sunlight, I later carried out some experiments that were arranged according to the same principle as the last-mentioned experiment with electric light; for this I used a collecting apparatus with a rock crystal lens of 10 cm.s diameter. The result was quite different here, as there appeared to be very little difference in the effect, whether the light had passed through rock crystal or through a thick mirror glass plate. Sunlight that had only passed through rock crystal had the same effect on Prodigiosus for 4 minutes as light that had passed through the glass plate had for 5 minutes.

1) These figures could not be considered as an absolute measure of the difference in the performance of the devices, since there are so many sources of error with regard to the cultures that these experiments have not taken into account (see S. BANG'S thesis: On the effects of light on microbes, Communications from Finsens's Institute of Light II. p. 1); but they do give an approximately correct idea of the great difference between the two types of devices.

This gives a fairly good practical impression of how great a difference there is between sunlight and the strong electric arc light with regard to the content of the outermost ultraviolet rays retained by glass. Sunlight has relatively few of these rays, based on the fact that the atmosphere absorbs them to a high degree. It follows, for example, that sunlight on high mountains is much richer in these rays than in the lowlands (see ABSALON LARSEN'S Aff.: Om Sollysets Intensitet. Meddelelser fra Finsens medicinske Lysinstitut I. P. 109). In the strong electric arc light, on the other hand, the vast majority of the bactericidal effect is due to these ultraviolet rays.

Theoretically, according to these experiments, one should use collecting devices with rock crystal lenses for both sunlight and electric light, since such devices would give absolutely better and more powerful light. But in practice the situation is different.

I will first mention how the situation is with sunlight. Since the rays here are parallel, the strength of the light, all other things being equal, will depend on the size of the area of the lens. This relationship is very favorable for those concerned with glass, since one can easily get glass lenses as large as one needs; but unfavorable for those concerned with rock crystal, since there are very narrow limits to the size of lenses of this type of rock. The largest rock crystal lens that I have seen and have been able to get is 11.5 cm. in diameter, but such are very rare and very expensive; on the other hand, one can fairly easily obtain rock crystal lenses of 7-8 cm. in diameter, although they are of course also expensive [1]).

From my experiments with bacteria described above, it became clear that one can approximately state the relationship between a rock crystal lens and a glass lens of the same diameter, same

1) While rock crystal lenses of 10-11 cm.s diameter cost 150-200 DKK., those of 7-8 cm.s diameter cost c. 30 DKK. Each.

Focal length and the same thickness, as 5 to 4, when it comes to utilizing the germicidal power of sunlight; in other words, only a very small increase in diameter is needed for a glass lens to be equivalent to a rock crystal lens. As an example, I would mention that a glass lens of 11 cm. in diameter would be equivalent to a rock crystal lens of 10 cm. But when one further considers how disproportionately the area increases in relation to the diameter, so that, for example, a lens of 20 cm. in diameter has an area 4 times as large as a lens of 10 cm., one will understand how disadvantageous it would be to use rock crystal lenses for sunlight.

It is different with electric light. First, the useful effect of rock crystal, as I have shown, is here so exceedingly much greater than that of glass, and secondly, the size of the area of the lens plays a much smaller role here, because the rays are divergent. When a lens with a small area is placed close to the light, it can, as is well known, receive an equally large or even larger amount of light than a lens with a much larger area, which is placed at a somewhat greater distance from the light. Of course, the size of the lenses is not absolutely unimportant, since there are certain practical disadvantages in their being too close to the glowing coal tips (they easily break, and are quickly dusted by the coal particles constantly falling down during the combustion of the coal). At a fairly large distance from the arc (12-15 cm.), these disadvantages are not very great, and in any case minor in comparison with all the advantages of using rock crystal. Even the high price of these lenses is of secondary importance when one considers

think of the enormous difference that exists between glass and rock crystal in relation to this light[1]).

1) This transition to the use of rock crystal lenses for electric light was, however, in reality a return, as I had already in Vienna

2. To which rays is the inflammatory effect linked?

I can limit myself to answering this question here in the shortest possible time, referring to my dissertation: "New Studies on the Effect of Light on the Skin" (Reports from the Finsen Medical Light Institute, I. S. 6), where I have made this question the subject of detailed research. The answer is that it is exactly the same rays that are effective in affecting bacteria, and that there is the same or approximately the same difference in the effect on the skin as on bacteria of electric light that has passed through glass and that which has passed through rock — crystal. [1]) Consequently, everything I have said in the previous section also applies to this section: In order to obtain the strongest possible effect of the light, it is most expedient to use rock crystal lenses for electric light and glass lenses for sunlight.

the year 1895-96 had used a rock crystal collecting apparatus for the treatment of lupus. The development was as follows: I began (in November 1895) with a glass lens, but quickly became aware that rock crystal was preferable from a — from theoretical point of view. I therefore obtained the same winter lenses of rock crystal. But when it turned out that they were so extremely expensive and could only be obtained in very small diameters, I went back to glass lenses. This return to glass was probably quite right at that time, because at that time I only had a weak arc lamp with relatively few ultra-violet rays at my disposal, and at that time I had not yet found the use of the double system of lenses (with parallel rays in between), which changed the situation completely and, so to speak, nullified the advantage of lenses with large diameters.

1) Whether these are exactly the same rays, one cannot of course say with absolute certainty, but as far as one can judge from the methods of investigation currently available, they are the same.

3. How can one get rid of the annoying heat rays most easily and best, without losing the beneficial bactericidal and inflammation-causing rays?

Completely getting rid of the heat of the light is a physical impossibility, since all rays of light possess the property of heating, only they have it to varying degrees. Therefore, in the question posed, I have only spoken of the "annoying" heat, and what I understand by this expression I can state quite definitely in numbers. By numerous measurements of the heat at the point of the light cone that the patients could tolerate without feeling pain, I have found that 45°-55° C. can be set as an average for what can be tolerated.

It was now a question of constructing apparatuses which could give a light cone with the strongest possible chemical luminous power without exceeding this temperature at the focal point. The work on this has been partly of a common nature and partly different for electric light and solar light, so that I must partly treat each separately.

I need hardly remark that hand in hand with these various investigations and, as a result of them, there have been constant constructions and new constructions of collecting apparatus, so that there are several links between the apparatuses which we now use and those which are mentioned in my above-mentioned book from 1896. It is not worth dwelling on most of these transitional forms; in the following I will only mention the most important ones.

Common to both kinds of light have been the investigations into the absorption of heat rays and chemical rays by water and various solutions. I had already carried out a number of investigations in this direction, and I mentioned them in my

Thesis from 1896, but the most important studies were carried out later.

The questions that it proved necessary to answer were, in the case of clear, colorless water, the following: What is the relationship with the absorption of water, a) of heat rays and b) of chemical rays, respectively. c) What is the significance of the thickness of the water layer, and d) What is the significance of the temperature of the water. This was followed by e) Studies on the light absorption ratios of different solutions in order to find the solution that was best suited to the collecting apparatus, that is, the solution that absorbed the most heat rays and the fewest chemical rays.

a). Water's Absorption of Heat Rays.

For these and the following experiments on absorption I used the light from a 35 Amp. arc lamp, concentrated by means of one of my electric light-collecting apparatuses of the type described in 1. c. p. 25. To determine the temperature I used a cattle silver thermometer, the ball of which was blackened with carbon black. The thermometer was kept in all the experiments at the same place in the cone of light, at the very focal point.

First I measured the temperature without filling the apparatus with water, it showed 325° C. (Average of 3 measurements 290°, 360° and 324°), then I poured water into the container of the apparatus, and now the thermometer showed 111°. (Average of 6 measurements, varying from 89°-123°). The thickness of the water layer through which the light had passed was 13 cm.

The rather large variation in the temperature, which was taken at fairly large intervals, is due to the lamp, whose light is rarely quite the same in the same place for a long time, for even if the current and voltage are kept quite unchanged, e.g.

The shape of the crater produces a large difference in brightness. For my purposes, however, these results were fine enough.

It is seen that the water layer has lowered the temperature of the light by over 200°. Since it is now known that water absorbs only a very small amount of the visible rays of light, this loss of heat must therefore be mainly due to an absorption of the invisible, ultra-red rays of light.

In order to find out whether all the ultra-red rays or approximately how many were absorbed by the water layer, I placed a light filter of 1 cm.s thickness, filled with an opaque solution of iodine in carbon disulfide between the apparatus and the thermometer (which solution absorbs all light rays, but is passable for the ultra-red rays), it now showed 26° (room temperature 20°). It can be seen from this that the water layer has almost completely removed the ultra-red rays. When I placed the same filter in front as a control experiment and at the same time emptied the water container of the collecting apparatus, the temperature in the invisible focal point went up to 172°.

b). Water's Absorption of Chemical Rays.

Of all liquid media, water is the most, or one of the most, permeable to the chemical rays of light, and experiments can convince one that the loss of chemical effect of light by passing through a layer of water is in reality quite negligible. When it comes to glass apparatus, one can even demonstrate that water is beneficial; if one measures the chemical effect of the light cone after it has passed an empty glass light filter, and then measures the effect after the light filter has been filled with water, one will see that the effect in the latter case is strongest; this is explained by the fact that the reflection from the glass sides is less when there is water in the filter than when it is empty. I have carried out my experiments on this in the following way:

—

let the light cone act on silver chloride paper (Aristo paper). In all experiments the paper was placed in the same place of the light cone, and the experimental time was the same in all comparative experiments. By then comparing the color of the spots blackened by the light, I was able to form a rapid and for my purpose sufficiently reliable estimate of the absorption of the chemical rays. As I have already stated, my experiments confirmed the great, almost complete permeability of water to these rays [1]).

c). The importance of the thickness of the absorbent water layer.

In practical terms, it matters a lot whether the Sanile apparatus should be constructed with a thick layer of water, or whether a thin layer can be sufficient. For the apparatus for electric light, however, it matters relatively less, since these apparatus are fixed and supported by strong iron arms. For the solar apparatus, on the other hand, the question is of great importance. When the water layer is large, the apparatus becomes very heavy and unwieldy; as an example, I will mention the solar apparatus described in my above-mentioned book, p. 24; it has a water layer of 40 cm.s thickness and holds about 10 liters of water. Because of its weight, it was difficult to transport and cumbersome to use and is therefore no longer used.

I carried out the above experiments with the same lamp, the same apparatus and in the same way as described on p. 11, gradually placing light filters of different thicknesses, filled with

1) As far as I remember, I have not noted anything about it in my experiment book. All my — experiments were carried out with distilled water, which we always use for the apparatus and light filters. There is, with regard to the absorption of the outermost ultraviolet rays, a considerable difference between ordinary water and distilled water (see ABSALON LARSEN'S thesis, Meddelelser II. p. 103).

Water, between the apparatus and the thermometer. Since I did not have filters of all thicknesses, I sometimes placed several filters next to each other, which does not correspond absolutely to a single filter of the same thickness[1]), but this, as is also evident — from the figures, does not play any — significant role in such rough experiments as mine.

The results of my experiments are found in the table below, in which I list the thickness of the water layer, the number of filters and the temperature.

Thickness of the water layer	Number of Filters	Tp. i Focus
0	0	325 ° C.
1 cm.	1	180 ° C.
2.5 —	1	126 ° C.
3.5 —	2	114 ° C.
13 —	no filter, but water in the device itself	111 ° C.
26 —	Water in the device + 1 Filter	107° C.

This table shows how important even a thin layer of water is, and how little benefit is gained by making the layer very thick. Consequently, a thick layer of water should not be used if this causes the disadvantage of making the apparatus too heavy and unwieldy, while it is expedient to leave the water layer thick where these considerations do not need to be taken into account. In the case of solar apparatuses, which have a large diameter and must be moved frequently, this, as stated above, plays a major role; therefore, in the latest designs of these apparatuses, I use a water layer of only 4-5

1) The more glass surfaces the light has to pass through, the greater the loss of light through reflection.

cm.s Thickness. In the case of the apparatus for electric light the relationship is reversed, the lenses have a small diameter and the apparatus is fixed, therefore one can use a thick layer of water here without any disadvantage; I therefore use a water layer of 35 cm in the newest forms.

d). The importance of the absorbing water layer temperature.

At first glance it might seem quite natural to assume that the temperature of the water layer must have some significance when it came to absorbing heat rays, so that cold water absorbed better than hot. This seems to be a common opinion, since almost all medical investigators who have worked with light without heat have emphasized that the light passed through a layer of water that was always kept cold. A decision on this question was all the more necessary for me, as the water in the light-collecting apparatus after a few hours of use becomes very hot, can almost reach the boiling point, and cooling the water, by constantly pouring cold water through it or in some other way, was a very laborious thing, which I would only take action on if it was very necessary.

My experiments on this were carried out with the same lamp, the same apparatus and in general in the same way as in the above-mentioned investigation. There was no water in the apparatus itself, but a light filter 1 cm thick was placed between the apparatus and the thermometer. This light filter was gradually filled with water at 5°, 45° and 73°, the corresponding temperatures, measured at the focal point, can be seen from the table below. I do not remember how many experiments I made of each kind, in my book it is only noted:

Filter of 1 cm.	Water 5°	174°
— — —	— 45°	— 198°
— — —	— 73°	— 180°

After these measurements, the variations of which could be considered to fall within the normal limits of error (see p. 11), I had in each case seen so much that there was no considerable difference in the absorptive capacity of the water, whether it was cold or hot, and I therefore considered it quite unnecessary to take the rather laborious measures of cooling the water in the collecting apparatus. When, however, I later (see p. 34) have come to the subject of cooling the water in the apparatus, it is for a different reason.

Before I conclude my discussion of water, I would like to point out that freshly distilled water must absolutely be used for both solar and electrical devices; apart from possible absorption conditions (see — ABSALON LARSEN'S above-cited article, p. 103), there are two practical considerations which make it unwise to use ordinary water. Firstly, as the water is heated, numerous air bubbles gradually settle on the lenses, thereby losing an extraordinary amount of brightness; secondly, ordinary water gradually deposits lime salts and other impurities on the lenses. We have also tried to use boiled water, but so far we have not been able to get it sufficiently clear.

e). Studies on the Absorption of Heat Rays and Chemical Rays by Various Solutions.

As mentioned in my above-mentioned thesis, pp. 20-21, I initially used a solution of methylene blue for my collecting devices, both for electric light and for sunlight, in order to remove even more of the heat rays of the light than water alone.

is capable of. In order to find out which solution performed best in absorbing heat rays and at the same time allowing the chemical rays to pass, I made a series of investigations.

First I examined spectroscopically all the clear soluble blue colours which it was possible for me to obtain; in doing so I found that methylene blue, alkali blue and an ammoniacal solution of sulphuric acid cupric oxide best met our requirements. The two first-mentioned showed by spectroscopic examination almost exactly the same absorption spectrum, however the spectrum of methylene blue was apparently the most favourable, and with this substance and the ammoniacal solution of sulphuric acid cupric oxide I therefore made a series of comparative experiments in order to determine directly, by means of a thermometer and photographic paper, their ability respectively to retain heat rays and to let chemical rays pass.

Since these are the same dyes that I mentioned in my above-quoted thesis, and since these later, more thorough investigations have shown that the assumption that I made at that time was not correct, I will state what I said about this situation in order to have it corrected at the same time. It is mentioned in 1. c. P. 20 in the following way: "since the ammoniacal solution of sulfuric acid copper oxide quickly discolors on contact with the metal sides of the apparatus and is otherwise less pleasant to use, I have now switched to a solution of methylene blue. The sulfuric acid copper solution, when sufficiently strong, certainly completely excludes the red rays, but a strong methylene blue solution does not. On the other hand, by a spectroscopic examination of a weak solution of the two colors, apparently of equal color strength, one will see that the methylene blue solution absorbs more red rays than the copper vitriol solution; and since one now generally only needs a partial exclusion of —

the red rays, the methylene blue solution is also preferable for this reason."

The experiments I will mention here were carried out with the same lamp and the same collecting apparatus as the above-mentioned experiments on the absorption of water, and with the same light filter of 1 cm.s thickness. The temperatures mentioned here could therefore be easily compared with the temperature (180°) mentioned above for a layer of water of 1 cm.s thickness; by such a comparison one obtains a numerical indication of the significance of filtering the light through blue-coloured water.

For the experiments I prepared two deep blue, apparently equally colored solutions of methylene blue and sulfuric acid copper oxide with ammonia. Then the light filters with these solutions were alternately placed in front of the light cone, after which the temperature was measured in Focus.

The result of the experiments was that I found an average of 61° for the copper solution, and 116° for methylene blue (for clear water the temperature was, as mentioned, 180° under the same conditions). By now testing the effect on photographic silver chloride paper, it was also shown that the same copper solution allowed more chemical rays to pass through than the methylene blue solution.

Then water was poured into the collecting apparatus (a water layer of 13 cm.). As a result, the Tp. as mentioned above was 111°; when the copper filter was now placed in front, the Tp. in Focus went down to 34°, when the methylene blue filter was placed in front, to 57°.

The solutions used here were, as mentioned, rather dark; in experiments with a weaker solution (the same solution half diluted with water) and with water in the collecting apparatus, the Tp. in Focus for the copper solution was 45° and for the methylene blue solution 58°1). From this last experiment it was found that

1) Since it may be surprising that this number is approximately the same as that found with the stronger methylene blue solution, I will state the result of the individual measurements. Both figures were averages of 3 measurements; at the strong solution the temperatures were 57°, 54° and 61°, at the weak 69°, 48° and 56°.

There is certainly some truth in what I said at the time about the difference between a weak and a strong methylene blue solution, compared with a copper solution. The main result, however, is that, both from the point of view of heat dissipation and from the point of view of the poor absorption of chemical rays, the ammoniacal solution of sulphuric acid copper oxide should absolutely be preferred.

Comparative experiments, arranged in exactly the same way as these last-mentioned, I have also made between an ammoniacal copper sulphate solution and various solutions which are stated to have a particularly great absorption capacity for heat rays, namely: solutions of alum, of sulphuric iron oxide, ferric chloride, etc.; but the result was that the copper solution proved to be far preferable to all of them. For these reasons we now always use copper solutions for the — collecting apparatus when more heat is to be absorbed than water alone is capable of. We try to reduce the disadvantages mentioned in the use of copper solutions (rapid decomposition, etc.) by coating the metal which comes into contact with the solution with asphalt varnish.

For the collectors of sunlight we still use copper solution, as it offers great advantages. For the collectors of electric light we also used it for a time, as long as we still used lenses of glass; but when the rock crystal lenses were introduced, the copper solution could no longer be used, as it absorbs the chemical rays to an even greater extent than glass in the liquid thicknesses of which we are here speaking.

4. Penetration of light into the tissues (Pressure glass).

In order to make the chemical rays penetrate as deeply into the tissues as possible, we always use pressure glasses, which press the blood away from the place to be treated, which, as I have shown 1. c. pp. 33-37, is of great importance. This is naturally of greatest importance where the treatment of deeply infiltrated parts is concerned. On the other hand, we have found that in quite superficial affections the goal can be achieved without pressure glasses; as an example I will mention a couple of cases of superficial lupus of the eye socket and upper eyelid, where it was not possible to use pressure glasses for the sake of the eye.

1/2 night. Size.

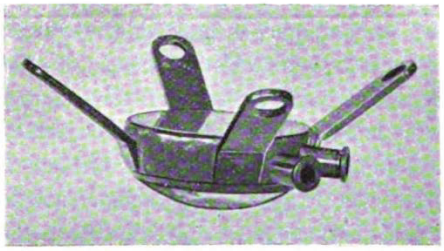
It goes without saying that the shape of these pressure glasses must vary somewhat according to the places where they are to be placed. In addition to the shapes previously mentioned, 1. c. p. 36, I would like to mention pressure glasses with a concave plate (for treating the eye socket) and a special shape, a small oval pressure glass with a stem (see Fig.) which we use in treating the corner of the eye and other places where it is difficult to place the usual 'pressure glasses.

Of greater importance is a change which I (1897) indicated in connection with the pressure jars, and which I will discuss in more detail, as it actually means in practical terms a very great improvement of the method. This change consists in using hollow, water-filled pressure jars, through which cold water is constantly flowing by means of an inlet and an outlet pipe.

In the constant striving to get rid of the troublesome heat of light, I had hitherto, as is evident from the foregoing, chiefly sought to achieve the goal by means of

of media which absorbed the heat rays. With regard to the importance of pressure glasses in this respect, I had only made the following experience: the sensation of heat was reduced when the glass was pressed strongly against the skin. But when one day I was making experiments on my arm with the light from a collecting apparatus, and the light burned strongly on the skin despite the fact that it had passed through a thick layer of water, we tried to sprinkle the skin with water; by this the sensation of heat completely disappeared. The same thing happened when a pressure glass was placed on the skin and this was sprinkled with water. By further experiments it was shown that even extremely hot spots of light, even such as immediately caused the most terrible pain on the arm, could be tolerated when the skin was covered with a pressure glass which was sprinkled with water.

Since constant irrigation would, however, present some practical difficulties in treating the patient, I tried to



2/3 nights. Size.

if one could not be content with hollow pressure glasses filled with cold water[1]), but experiments showed that although these provided much benefit, the advantages of the constant change of the water were so disproportionately great that I decided to introduce the

1) While, as I have shown above, it is quite unimportant whether the water in the containers of the collecting apparatus is hot or cold, since the water's ability to absorb heat rays is roughly the same in both cases, the situation is quite different with the water in the pressure glasses, which is supposed to have a cooling effect by conduction; in this case, it naturally cools the skin more strongly the colder it is.

mentioned hollow pressure glass with a trickle. By this change the pressure glass, or as they should rather be called, the pressure apparatus, have been given two tasks, namely to press the blood aside, and to have a cooling effect on the skin (by conduction). These two tasks are so important and essential and of such great practical importance that the third effect they exert, namely to absorb heat rays, can be left completely out of consideration from a practical point of view. If there were no water in the collecting apparatus, the importance of this would be great, since even a thin layer of water (see my table p. 14) is of extraordinary benefit. But since there is no disadvantage in placing a layer of water in the collecting apparatus itself, on the contrary a great advantage, since here one can make the water layer, in the one case (electric light) very thick, in the other case (sunlight) blue-coloured, this is of course to be preferred. From the aforementioned table, it can also be seen that the absorption of heat rays by pressure devices is practically meaningless, since almost all the heat rays that can be absorbed by water are already absorbed by the collecting devices themselves.

The great practical significance of the introduction of these pressure devices with water permeation for the method will perhaps be best illustrated by the following experiment. I placed on my arm a hollow pressure device, through which water at 12° C. flowed, and then exposed the arm to the light cone from a large solar collector (a water lens of about 30 cm. diameter with clear water). I now tried how close to the focal point I could bear to hold my arm without feeling any pain. The distance from the lens was then measured, and in the very same place a cattle silver thermometer was now placed, the ball of which was blackened with carbon black. The Tp. turned out to be 220-230° C.; a stick, which was held in the same place, that is, where my arm had been, immediately emitted large clouds of smoke and glowed. When one now considers that the

The Tp. of the light cone, which one could generally tolerate with the pressure devices used up to now, was 45°-55° C., then one will understand how great the significance of this improvement in the pressure devices was, and how much stronger light we could use for treatment after their introduction. While previously we could not use lamps stronger than 35-50 Amp., we could now use them at 60-80 Amp.

The condition for the skin to be exposed to radiant heat without pain and without injury, which would otherwise char it, is of course that the cooling 2: The dissipation of the heat occurs more rapidly than the heating of the skin by absorption of the rays. A substance that conducts heat well is therefore preferable, and since rock crystal, like other precious stones, is a far better conductor of heat than glass, it is theoretically preferable to glass for printing apparatus. I would add that this difference in conductivity is large enough to have practical significance. When, as mentioned above (p. 6), we introduced rock crystal lenses for the collecting apparatus for electric light, we of course also introduced rock crystal into the printing apparatus; one can therefore see that there are two reasons for the use of rock crystal here; and one now understands the apparent inconsistency in the fact that for sun treatment we use glass collecting lenses, but rock crystal pressure devices.

Collectors for Sunlight.

The form of these has changed not so little in the intervening time as a consequence of the above-described investigations into the absorption of light. From the form of collecting apparatus which is described 1. c. p. 24 to the form which we use at the present time, and which has not undergone any essential changes during the last three years, there have been numerous transitional stages. Although it might seem unnecessary to mention

These transitional forms, I will however mention some of them, in order to have the opportunity to state why we have not been satisfied with these forms; this is the best way to avoid others going the other way in the belief that they are making improvements.

The solar apparatus, which is described 1. c. P. 24 but which was far from the first form, consisted of two massive glass lenses, one 30 cm. in diameter and the other 18 cm. in diameter; between them was a water layer 35 cm. thick. The apparatus held about 10 liters of water and was very heavy to transport and set up, and so difficult to move that we often preferred to move the patient when the movement of the sun made movement necessary. In the studies mentioned above (P. 14) on the significance of the thickness of the water layer, it turned out, however, that such a thick water layer was of relatively little use. I therefore constructed the next solar apparatuses with much thinner water layers, which made them much easier to handle.

As the large solid glass lenses were relatively expensive, I tried to get myself hollow glass lenses; but as I was not so lucky as to find a glassworks that could and would make them, I tried large watch glasses, which were putty into a metal ring; these lenses were considerably cheaper, but only became really useful when I had curved glasses made especially for this purpose. This was only possible after numerous unsuccessful attempts, as there are some technical difficulties in making them of large size and exactly spherical.

However, it soon became apparent that for reasons to which I will return later it was impractical to use the very large lenses (40 cm. in diameter). The size 20-30 cm. in diameter proved to be most suitable, and glass of this size was not so difficult to obtain, but only with a fairly strong curvature. The result of this was that Lindsen's fire-

width became rather short (30-40 cm.), and that the collecting apparatus always had to be placed very close to the patient. When this proved to be no small disadvantage, I proceeded to make one side of the Lindsen plane by inserting mirror glass instead of the one curved glass; this made the focal length twice as long, and the use of the apparatus much more convenient. This is the simple reason why the Lindsen in the solar apparatus is always plano-convex, a condition which still raises many questions.

However, I have not yet succeeded in obtaining as good glasses as I could wish. Due to the method of manufacture, as far as I know, a large — sphere is first blown, from which the glasses are cut out as segments, they are never perfectly accurate and never collect the light as well as ground, solid lenses; the light spot at the focal point is most often irregular (angular, oval, etc.). When I thought that perhaps more was actually lost by this irregularity than was gained in the other direction, namely by the cheapness of the lenses (they were about 10 times as cheap as the others), I again switched to trying solid glass lenses, but in such a way that I only let one side of the apparatus consist of a lens (plano-convex, with the flat side facing the water), while the other consisted of a flat mirror glass plate.

This achieved the advantage that the light was collected beautifully, so that the light cone was regular and the spot round at the focal point. Next, there was the additional advantage that the blue-colored water layer was equally thick everywhere. When the Lindsen, on the other hand, is formed of a curved glass, the water layer is of course thickest in the middle, which is unfortunate, since the central rays (which must be assumed to be the most favorable, as they are collected best and refracted the least) will pass through the thickest water layer and thereby be absorbed more strongly than the peripheral rays, which pass through a considerably thinner water layer.

But when I then made comparative experiments with two devices of the same diameter and under exactly the same conditions, it turned out that the device with the curved glass, despite its poorer ability to collect light, killed bacteria more quickly than the device with the solid lens. This difference must therefore be due without a doubt to the greater absorption of ultraviolet rays by the thick glass. Here, therefore, the cheapest was also the best.

In order to remedy, if possible, the disadvantage that the blue layer of water, as mentioned, was thicker in the center than in the periphery, which was particularly important with the large apparatuses, and when the liquid in strong sunlight was to be relatively dark in color, I made a number of experiments.

I constructed some apparatuses, the lens of which was filled with clear water, while either in front or behind it was placed a light filter with flat walls, filled with the blue solution. In other apparatuses, plates of blue glass were placed instead of filters, so that in weak sunlight one could be satisfied with one plate, in stronger sunlight with two or more. The apparatuses with light filters, however, were abandoned because they became too heavy and unwieldy, the apparatuses with the blue glass plates because it proved impossible to obtain glass of a suitable color. In comparison with colored solutions (copper solutions), it turned out that the blue glass allowed more heat rays and fewer chemical rays to pass through than the blue solution. Next, I tried to coat the flat surface of the lens with transparent blue-colored gelatin, but this also did not prove practical. All these and several other methods of achieving uniform absorption of heat rays over the entire area of the lens later proved to be quite redundant, as I gradually became aware that there was no advantage in using very large lenses.

It was shown by experiments that when the liquid was

made very deep blue, — which was necessary for the large lenses, because they heated so strongly, it absorbed so many chemical rays that the advantage that one should have from the large area of the lens was actually lost, so that these large lenses often even gave less than lenses of considerably smaller area, filled with a brighter solution. Experience has therefore shown that for this reason, at least below our latitude, it is impractical to use lenses of larger diameter than c. 30cm.

One might ask here whether it would not be wiser to use the large lenses and thus make the treatment spot larger, thereby simultaneously treating a larger area. However, this could not be done because the light outside the focal point of the lens is collected far too unfavourably to be used. If one wants to use the light inside the focal point (between the lens and the focal point), one gets a disproportionately strong amount of light in the periphery of the spot and very little light in the center; if, on the other hand, one wants to use the light cone outside the focal point, one gets the exact opposite, namely too strong and warm light in the center and very weak in the periphery. These conditions can be easily and clearly convinced of by placing photographic silver chloride paper at different points of the light cone and examining the shape of the blackened figure[1]).

I must also add that I have tried, instead of using lenses, to collect the sunlight with a silver parabolic mirror; but I quickly gave it up when the collected light was

1) I must note, however, that the task could be partly solved by making solar apparatuses with a lens of very weak curvature; such a lens would give a good focal point of a larger area; but, firstly, I have not yet succeeded in obtaining such weakly curved large glasses, and secondly, the very long focal length that such a lens would have to have would entail such frequent movement of the collecting apparatus that the advantage of such apparatuses would possibly be small or none in practice. Experiments should, however, be made with such lenses when they can be made.

extremely hot and at the same time relatively poor in chemical rays. I have also mentioned above (p. 6) that I have made comparative experiments between solar apparatuses with glass lenses and with quartz lenses.

The result of these investigations and of the experiments with the above-mentioned and several other types of collecting devices is that for the time being I have settled on a solar device of the form which I will now describe, and which can be seen in the accompanying picture.

The apparatus consists of a tripod and a lens. The tripod, which is intended to be placed on a table, carries a fork at the top, which in turn carries the collecting lens. The latter can be rotated about a vertical as well as a horizontal axis and can be raised and lowered according to the sun's high or low position.

We have the collecting lenses of different diameters and different focal lengths; but the dimensions which I consider most favourable for Danish conditions are a diameter of c. 25 cm., a focal length of c. 70 cm. and a distance between the two glasses that form the lens of 4-5 cm. in the periphery. Whether one wants to use a biconvex or planoconvex lens can be of no importance, only one should ensure that the glasses are as thin as can be combined with a sufficient strength. These collecting lenses are filled with distilled water, which is colored blue with an ammoniacal solution of copper sulfate, which of course must always be quite clear and transparent. The strength of the solution cannot be precisely determined, as it must vary according to the strength of the sunlight. A solution of medium color can be considered to be 0.3 grams of sulfur. cupric., dissolved in 900 grams of distilled water, to which 100 grams of ammonia water (4%) have been added. If one wishes to strengthen or dilute the solution, this is done by adding more or less copper sulphate; the amount of ammonia, however, should always be the same. A stronger solution than 3 times as strong as the above should not be used, as

too many chemical rays are then absorbed. If the light nevertheless heats too much, which is hardly likely to happen with a — lens of 25 cm. diameter, it is better to cover a larger area than to make the liquid bluer.

1/5 night. Size.

or smaller segment of Lindsen. I need not state any limit to the strength of the solution downwards, since it is of course most advantageous for the chemical rays to have the liquid as little coloured as possible. If the sunlight on some occasion heats it so little that the liquid can be made quite clear, it only means that one with greater

It would be advantageous to use a lens with a larger diameter and with blue-colored liquid.

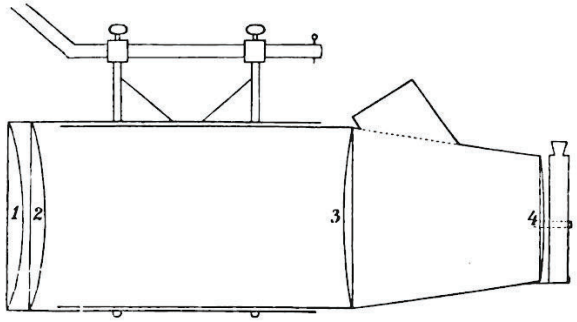
In addition to these devices, the sun treatment also requires small tables, which should preferably be firmly fixed and have a top that projects freely to the north (since the table legs interfere with the positioning of the patients), as well as a water line to the pressure glasses. Since it may be of interest to those who would like to take up this treatment, I will describe how the sun treatment is arranged here at the Light Institute.

In the yard where the sun treatment takes place, two rows of small tables (28 in total) have been set up. The table tops, which are either round, with a diameter of half a meter, or square, are supported by a pole driven into the ground. The distance between the tables is 21/3 meters. Along the row of tables, up in the air, resting on supports 21/4 meters high, are placed water pipes, which, just above each table, give off a drain pipe equipped with a tap, from which a gutta-percha tube runs to the pressure glass. From this, a tube runs to a drain pipe placed under the table, which opens into a drainage channel running down into the ground. This water pipe, as well as the one for the treatment with electric light, caused me some difficulty at first, as the water pressure was too strong; but now that I have arranged it so that the water pipe is not directly connected to the city water pipe, but comes from a tank placed at a height of about 3 m. (up in the ceiling above the treatment room), it works very well and easily. The tank has a supply pipe that is provided with a tap with a float, so that it is always kept filled to a certain height. In the bottom of the tank there are drain pipes that supply both the solar treatment water pipe and the water pipe for electric light treatment. For safety reasons, the tank is provided with a drain pipe near its upper edge, in case the tap or float does not work.

Sunlight treatment.

Collectors for electric light.

These devices, like the solar collectors, have also undergone some changes in the past, but not as many as those. The most important and significant change is that, after an experiment (mentioned on p. 5) in May 1897, I introduced lenses exclusively of rock crystal instead of glass. But since before this experiment in



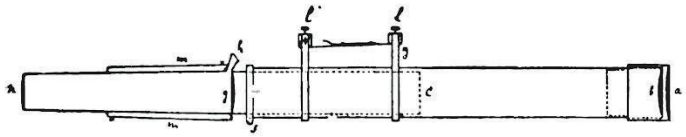
1/10 night. Size.

For some time, glass collecting devices of a somewhat different construction than those described on page 25 had been used for the treatment of lupus patients, and since I have not yet described them in any Danish treatise, I consider it most appropriate to give a brief description of them.

As can be seen from the accompanying drawing, which shows such a collecting apparatus on average, the difference between this and the one mentioned above is that there are 2 plano-convex lenses closest to the light instead of 3, and that the water layer is limited by two also plano-convex lenses. The lenses are of considerably larger diameter (25 cm. instead of 17) and the water containers hold about 10 liters of water. While the water container in the first apparatus was filled with the blue solution, in the latter it was filled with clear water, while the blue solution was placed in a "light filter",

c: a flat glass container, which was placed in front of the lower lens. There were several such light filters with different strong resolutions, so that by changing them one could quickly and easily make the light more or less warm according to the patients' wishes.

However, we had not had these relatively good devices for very long (10 months) before the introduction of devices with rock crystal proved necessary. As can be seen from the above studies, these devices had to be



1 10 night. Size.

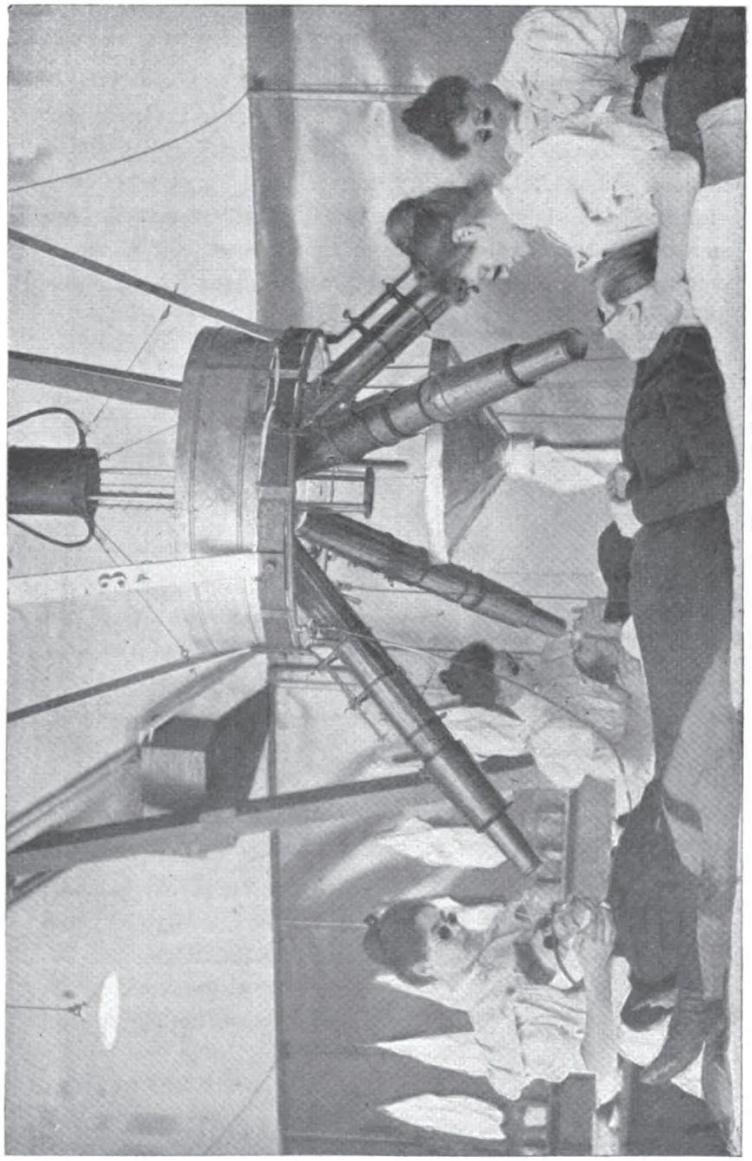
only rock crystal and only clear water are used. The change that was necessary from the form just described, which had otherwise proven to be very practical and good, was in particular that the light filter was dropped, and that the metal tube became of much smaller thickness, instead of 25 cm. in diameter it was now only 7-8 cm., because rock crystal lenses of larger diameter are difficult to obtain. By this change, the collecting apparatuses, as is evident from the accompanying average figure of the apparatuses now in use, have come to resemble binoculars, a comparison that is so natural also because the two metal tubes, like in binoculars, can be pulled out and pushed into each other. While the mutual position of the lenses corresponds entirely to the described apparatus with glass lenses, the long, thin shape of the apparatus has caused some differences. On the one hand, I have been able to make the water layer very thick (c. 35 cm.) without any disadvantage, and on the other hand, I have had to take special measures to center the apparatus in relation to the light point.

Since it cannot be avoided that the point of light, even if the lamp burns with a so-called fixed focal point, changes position in 3

small degree, — whether it is caused by the coals burning a little irregularly, or by the lamp moving a little - the result will be that the light falls a little crookedly into the tube, and since the path through it is so long and the tube so thin, it gives a large deflection at the lower end of the tube, where the light comes out. To compensate for this, it is first necessary, with the help of guy ropes and a so-called "fence wire tensioner", to fix the lamp as well as possible in the center of the ring that carries the 4 collecting devices (see picture p. 36); but then also to hang the devices in such a way that they can be centered. This is done with the help of 3 screws, which are located at the lowest suspension point of the device on the arm of the stand, while the center around which it rotates is located at the upper suspension point.

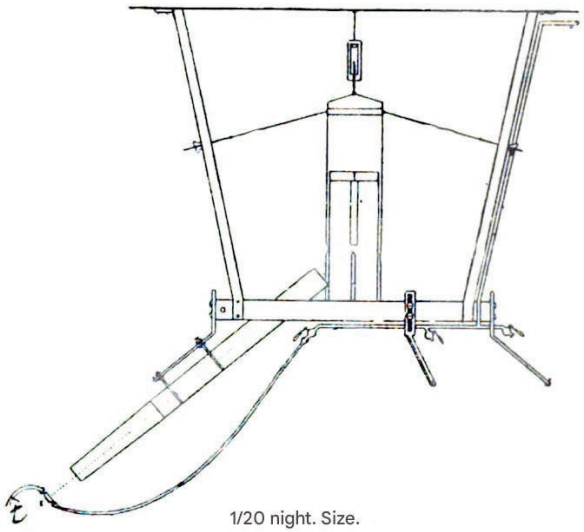
In the latest rock crystal collecting devices, the upper half of the tube containing the water is provided with a double wall, through which cold water can be passed and thereby cool the water inside the container without changing it. The water inside the container must be distilled water, while the cooling water is ordinary water. The reason why I have placed such a "cooling jacket" on the devices is, as is apparent from my above-mentioned experiments (p. 16), not that the water absorbs heat rays better when it is cold; but rather that the water in the devices often becomes very hot, and if a lens were to burst, the hot water would flow down over the patient and possibly scald him; furthermore, it is quite likely that the devices will leak more easily when the water becomes very hot. Since for other reasons (as mentioned on p. 22) a water pipe had to be established for the treatment, it did not cost much trouble to cool the collecting apparatus at the same time.

The last change made to the apparatus is that the tube forming the water container has been designed to be separated in the middle into two parts, the two parts being screwed together.



Treatment with electric light.

together and kept watertight by an interposed gutta-percha ring. Even better, however, is what we have recently introduced, to separate the tube in two places, immediately at the two lenses which close the tube.[1]) This is done to facilitate the cleaning of the inner surface of the two rock crystal lenses which limit the water layer above and below. That a very careful cleaning and frequent changing of the water in the



1/20 night. Size.

The necessity of the holder turned out to be quite amusing; in the beginning we only cleaned the lenses once a week, but it soon became noticeable that the reaction of the patients was often strongest the day after this cleaning, and it now appeared on closer examination that a frequent and

1) This change was proposed — simultaneously but independently by me. by Professor v. PETERSEN from St. Petersburg.

Pleasant cleansing is a necessity if one wants to obtain the full benefit of the light.

Very recently I have also provided the apparatus with a metal cover which closes off the lower part of the tube, where the light comes out. The cover resembles those used to close off a photographic camera; the only difference is that this cover is provided with a number of small holes. The purpose of this cover is to make it more convenient for the nurses to "adjust" the patients. Through the many small, regularly distributed holes, minimal amounts of light come through, whereby the same light image (focal point) appears as otherwise, only quite dimly, so that one can easily bear to look at it without dark glasses. The adjustment is done in this way much easier and more accurately, and only when the diseased part is in the right position to the light, and everything is in order, is the cover removed, and the full, strong light now falls on the patient. However small this improvement may be, it represents a very great advantage both for the nurses and for the patients, who were previously much disturbed by the strong and burning cone of light during the adjustment. These perforated sheets are also very useful in centring the apparatus; when you hold a piece of paper immediately in front of the sheet, you will see all the holes as small bright spots, and if these spots are not equally bright over the entire periphery, the apparatus is not well centered.

From the accompanying pictures you will see the way the apparatus is suspended, the position of the patient, etc. A couple of years ago, the stand that carries the apparatus was changed so that it is not supported by — supports that are fixed to the floor, but by supports that extend from the ceiling; this achieves both greater stability and better space for patients and nurses.

What is the difference between sunlight and electric light, and when should one use one and when the other?

The difference between sunlight and electric arc light, which has practical significance for us, can be briefly expressed as follows. 1) Sunlight contains relatively more heat rays in relation to chemical rays than does strong electric arc light. 2) The chemical rays of sunlight have their maximum at a different place in the spectrum, namely nearer the red end, than the electric arc light.

The theoretical conclusion that can be drawn from point 1 is that the electric arc light is better suited for this treatment than sunlight. Since the conditions for and the means for removing the heat rays are the same and identical for both types of light, according to this, with the same degree of heat at the focal point, one will get a stronger — chemical effect from the electric light cone than — from the solar light cone.

The degree of heat in the focal point of the light cone is the decisive factor when it comes to how strong light it is possible to use for treatment. For we do not yet know of any reason that speaks against using even the strongest possible chemical light for treatment, and until we learn of such a reason, one must of course strive to reach higher and higher in the direction of the strength of the chemical rays. However, it must be added here immediately that the chemical rays must be of the kind that have the property necessary for therapy of being able to penetrate well into the depths (see more about this later).

While the temperature at the focal point of the light cone that could be tolerated by the patients without water irrigation of the pressure apparatus was about 50° C., after the introduction of water irrigation, as mentioned, it rose to a little over 200° C.

With the latter degree of heat as the upper limit, one can therefore try to determine how strong the light can be.

use. As for sunlight, it is not so easy to get a definite measurement, since sunlight is so different at different times of the day and different seasons. As said above, I will assume, however, that lenses of about 25 cm diameter are most suitable.

As for the electric light, one can come somewhat closer to the determination. Experience has shown that with the ordinary arc light (carbon electrodes) and with my above-mentioned collecting apparatus, one cannot use stronger light than about 70 Amps. At 80 Amps, the light cone becomes so hot that many patients could not tolerate the treatment.

A more detailed comparison of these two kinds of light will appear later, together with the assessment of the various other light sources and the various treatment devices. Here I will only mention a few details from which one can roughly see the difference.

After the studies that we have done on bacteria, I would assume that under otherwise the same conditions, it would take a couple of minutes to kill Prodigiosus in plate culture with strong sunlight, while with electric light you only need a couple of seconds to do so. With regard to the visible effect on the skin, I cannot give such definite figures; in general, I can only say that the daily experience of treating patients shows that they get a much stronger skin reaction to electric light than to sunlight. It can certainly be said that sunlight does not usually cause blistering, while with electric light blistering is the rule (the treatment time is 5/4 hour). Incidentally, with regard to this question I would refer to my dissertation ("New Studies on the Effect of Light on the Skin". Messages from the Finsen Medical Light Institute. I. p. 6). Herein (p. 12) is mentioned a comparison of two experiments on my arm with unconcentrated sunlight and unconcentrated electric light, the results of which

The result was that the inflammation that appeared on my skin after 3 hours of exposure to sunlight (the experiment was carried out from 12-3 in the first half of August) was not as strong as that which appeared after 20 minutes of exposure to electric light (80 Amp. lamp, 50-75 cm. distance).

From what I have stated here, one will get a fairly clear picture of the superiority of electric light, and yet it is strange enough that we at the Light Institute have not received any definite impression, in the case of lupus treatment, that the results of the treatment are worse during the time when there is a lot of sun treatment than in the winter, when we do not use the sun at all; on the contrary, we have, at any rate in the past, been inclined to attribute to sun treatment a more favorable effect on the patients and a more favorable course of the treatment. [1]). If this estimate is correct, we are faced with an apparent difficulty in explanation; but only apparently, for the probability suggests that there is another factor here that must be taken into account, namely the general condition of the patients. And that the general condition of our lupus patients is better in the summer than in the winter is a certain experience. This is probably partly due to the same reasons that are the reason why summer is generally the most favorable time for patients with tuberculous diseases, but it is perhaps not least due to the fact that local sun treatment is combined with a stay in the open air and sunshine and is thus a kind of general treatment in sunlight. Moreover, it must be remembered that it is a common experience - it is something we still hear from our lupus patients - that the local affections often spontaneously improve in the summer and worsen in the winter. For these various reasons, it is therefore not surprising that sun treatment apparently gives — just as good or even better results.

1) This perception, which is a pure illusion, must now probably be changed somewhat.

results in Lupus vulgaris than the stronger electric light. The situation is quite different, however, with the other skin diseases which we have successfully treated with concentrated light. Both in the treatment of Lupus erythema-tosus, Alopecia areata, and in telangiectasia, electric light shows its superiority to such an extent that it is perhaps best not to treat these diseases with sunlight at all 1). This difference in the effect on these different diseases is in itself quite characteristic and may perhaps be interpreted with some justice as a sign of the importance of the general condition for the improvement or cure of Lupus vulgaris"). The practical consequence of this difference in the effect of the two kinds of light - a difference which, however, it must be remembered, was not present in the first years of this method, but is a consequence of the introduction of rock crystal — instead of glass - is of course that we now use sunlight much less frequently than before. The use of sunlight is restricted to the brightest part of the year (May-September) and the brightest part of the day; in general we now only use sunlight when the weather permits treatment in the open air. The fact that we do not use sunlight in winter or at all when the sun is low is also justified by the circumstance that sunlight when the sun is low is not only absolutely, but also relatively poorer in chemical rays than when The sun is high. This is due to the atmosphere, which has

1) It is, however, possible that better results could be achieved with very long sessions.

After this was written, I have come to think that this relationship could perhaps be explained in another way and based on the difference between the two kinds of light (0: the different position in the spectrum of the There is much to suggest that we chemical rays maximum). 2) have unfortunately not yet been able to investigate more closely that the less refractible the rays are, the more — easily they penetrate the tissues in depth. The explanation could therefore be that sunlight has a stronger effect in depth than electric light.

the property of absorbing far more chemical rays than heat rays. By looking at the tables of the intensity of the sun's rays in Copenhagen, calculated by the Light Institute's physical employee, cand. mag. ABSALON LARSEN [1]), one gets a good impression of the extent to which this is the case. A few figures will best show this. If we take the value of the heat effect of the direct sun's rays on June 21 at noon to be 74, it is 34 at 7 in the afternoon; if we take the value of the chemical intensity on the same day at noon to be 119, it is only 5 at 7 in the afternoon. On December 21 at noon we have approximately the same solar altitude as on June 21 at 7 in the afternoon, and the figures are therefore approximately the same, namely the heat effect 33 and the chemical intensity 4.

At first, and before I knew these figures, I thought that the lesser power of the sunlight in winter could be compensated for by using larger lenses, but by testing the chemical effect of the cone of light, when it was as strong (5: hot) as the treatment allowed, it turned out that the chemical intensity was extremely small; but only after the exact tables were available was I able to clearly see the conditions.

Even if one did not have precise physical studies of these conditions, one could nevertheless conclude that by immediate assumption. As is known, the sun is red when it is near the horizon and becomes whiter and whiter the higher it rises in the sky. This shows that the red rays, the heat rays, are in such an extraordinary predominance when the sun is low. Conversely, the color of the sun actually becomes more and more bluish the less atmosphere the light has to pass through, so that its color, if one could observe it from a point outside the atmosphere, would appear blue (Langley).

1) ABSALON LARSEN: The Intensity of Solar Rays, Reports from Finsen's Medical Light Institute I p. 121.

With regard to our use of light, the difference between the two types of light has the technical significance that, as discussed in detail above on pp. 7-8, it is most advantageous to use rock crystal lenses for collecting devices for electric light and glass lenses for collecting devices for sunlight.

What possibilities are there for improving the method?

Already in my first communication about this method I strongly emphasized that there was a certain possibility of extremely great improvement of the method, both in the direction of better apparatus and in the direction of better light. Although in the past 6 years as I have described above very great improvements have been made both with regard to the light and with regard to the apparatus, especially the latter, there is no doubt that the method can still be improved and will be improved considerably. I will briefly indicate in which directions the development must be assumed to go.

The improvement of light will consist in providing light that is as rich as possible in chemical rays and as poor as possible in heat rays.

With regard to sunlight, an "improvement" can only consist in seeking those times and places where the sunlight meets the given conditions to a particular degree. I have touched on this question above (p. 41) and shown that sunlight in our latitude is only suitable for light treatment at certain times of the year and at certain times of the day. One must of course be familiar with these conditions when one wants to use sun treatment. The location of the place is also of great importance.

We know that the atmosphere preferentially absorbs the chemical rays; therefore, sunlight will be much better suited for

action in places where the air is light and clean, while places where the air is filled with dust particles or water vapor are less fortunate. For these reasons, sunlight is usually stronger on land than in large cities with their smoke-saturated atmosphere, and stronger inland, where the air is relatively dry, than by the sea, where it contains much more water vapor.

Of greatest importance, however, is the height of the place above the water surface; the higher the location of a place, the thinner the layer of air through which the light must pass, and the greater the chemical intensity of the light. There is also the advantage that the air temperature at high altitudes is not as high as at lower altitudes at the same latitude. The heat is of great practical importance. Even here in Denmark, when undergoing sun treatment on hot summer days, it is difficult enough for both nurses and patients to endure the heat in the middle of the day. The further south one goes, the worse it naturally becomes. In Greece, for example, it has been found that sun treatment must be postponed for this reason to the morning hours, while the sun is still low; however, this is unfortunate, since the chemical intensity of sunlight, as mentioned above, decreases relatively strongly with low sun altitude.

The discomfort caused by the heat in this way is actually so great that one can practically say that there are more favorable conditions for sun treatment in the northern countries than in the southern ones. If one could make such arrangements that nurses and patients were shielded from the sun and not suffer from the heat, while still receiving direct sunlight on the sun apparatus, that would be another matter.

It will be seen from this that if there is talk of establishing a larger phototherapy facility or a sanatorium for lupus patients, especially in the southern countries, it will be very

It is expedient to place it on a high place. And besides, apart from the great economic importance of using sunlight rather than expensive electric light, there is the advantage that in such a place, due to the great chemical intensity of the light, one will probably be able to achieve quite different favorable results than we have been able to achieve with sunlight in this country. The idea of establishing such an institution or sanatorium for skin tuberculosis on a mountain cannot seem so daunting at the present time, since sanatoriums for pulmonary tuberculosis are being established on mountains. Perhaps it would be most natural and easiest to establish such lupus treatment institutions in connection with mountain chest disease sanatoriums, especially since these often already have electrical installations for lighting. Cooperation would be easy here and could perhaps even be done without any additional electrical system, since the light treatment on days when there was no sun could be carried out during the day, when electricity was not used for lighting anyway. At the same time, there would be a good opportunity for the not few lupus patients who also have pulmonary tuberculosis to undergo a curative pulmonary tuberculosis treatment. This combination of lupus treatment and phthisis treatment is already carried out in practice here at the Light Institute, since, on Dr. BANG's initiative, we have set up a lounge for the chest-sick lupus patients; at the same time, we have also strived to improve their nutritional status by distributing milk and hematin-albumin to poor patients. (Since the patients do not live at the Institute, we could only partially take care of their nutrition).

This proposal for mountain lupus sanatoriums is admittedly a little outside my subject, but may perhaps have some practical interest now that so much can be done, and that therefore hopefully something will also be done for the unfortunate people who suffer from lupus, in the same way as is done for those with chest diseases. And that the disease in most countries is common

sufficiently common and widespread enough to justify such extensive measures, there can be no doubt about it, after we have learned how widespread it is in Denmark, which is not, however, a particularly tuberculous country.

But to return now to the subject: the possibility of improvements in the light source, we are quite differently free to make improvements when it comes to artificial light. Since this is of such great importance, we have been working on this task for some time now. The investigations were first aimed at 1) determining, by a comparison between different types of arc lamps, which one was best suited for us. Next, it was a question of determining 2) whether the light from the arc or from the coals was the best, and finally 3) at what voltage the light was best for our use. For the determinations we have used partly chemical reagents, silver chloride paper and silver bromine paper, and partly bacteria. These latter are absolutely the best and most practical means of determining the intensity of the light, since it is precisely the intensity, or rather the type of light, which kills bacteria that is important to measure. By a long series of investigations of this kind, which I will not go into in detail here, we have found that the ordinary arc lamp in the form which we use at present, and which is partly constructed for our use and according to our requirements, is preferable to the others which we have tried.

To investigate whether the light from the arc or from the glowing positive carbon tips was the most bactericidal, I formed an image of the arc and carbon with the aid of a collecting lens of rock crystal, and let it fall on a plate culture of B. prodigiosus. The next day the culture showed, quite like a photograph, which parts of the light had affected the bacteria most strongly. The least influence was found where the arc had been, a little stronger for the negative carbon, but far stronger for the positive carbon. (This does not mean, however, that the relationship is not

may turn out to be different with a different type of arc lamp).

The studies with regard to the voltage showed that the voltage that was most favorable for the lamp (c. 50 volts) also produced the most bactericidal light.

The changes which we have made to the lamp, really only concern its external form; thus the distance between the side rods has been made very large, so that they should take as little light as possible from the apparatus. In order that the regulating mechanism of the lamp should not be heated too much, an asbestos screen has been placed over the coals. Furthermore, the lamp is arranged in such a way that it can be lashed absolutely firmly in the middle of the ring which carries the apparatus.

The reason why I have mentioned these studies so briefly is that the Lighting Institute has recently been working diligently on new lamps with different types of electrodes.
These lamps seemed at first to promise good things, but have not lived up to expectations. They have, however, taught us that more detailed investigations are needed into the ability of the individual types of radiation to penetrate through heat, and that it will be of little use to continue working on new lamps before this question is fully elucidated. But, as it is, all probability indicates that the future will bring better lamps than those we use at present, since the lamps we use are designed for the purpose of lighting, but not for the purpose of causing inflammation and killing bacteria. When it first becomes clear to those experts in this field that they must design something new for medical use, then it will most certainly come.

The second way to improve the method is through improving the apparatus. I have said something about these in the preceding section and will therefore be brief here. Although the forms which we use at present have emerged as a

The result of extensive research, however, would be quite unreasonable to believe that they could not be improved in many ways, - both solar apparatus and electrical collecting apparatus and printing apparatus, but in what these — improvements should consist, it is not so easy to say at the moment. One of the most natural improvements, which we have already been experimenting with for some time, is to try to treat a larger area at once, i.e. to arrange the apparatus and lamps in such a way that the spots of light become larger without the intensity of the light becoming less. With the ordinary apparatus with lenses of 7 cm. diameter, one would thus be able to develop a spot of 7 cm. diameter, instead of 11/cm. diameter as now, if one inserted flat rock crystal plates in the lower tube instead of collecting lenses. In order to achieve the same effect, of course the intensity of the light must at the same time be increased very considerably. Such an enlargement of the light spot would be very beneficial in widespread cases, but would be quite unnecessary in less widespread cases. It will therefore probably be the case that one gets devices with light spots of different sizes at the same time as we already have the arrangement to have light spots of different intensities.

A very practical improvement has recently been invented by Dr. REYN. Since the lens closest to the light frequently cracks, Dr. REYN has found the solution of using water cooling for this lens. This is done by placing a flat rock crystal plate about 2 cm in front of the front lens. In the space thus created there is distilled water which is cooled by a water current constantly circulating around it. This not only prevents the expensive lenses from cracking, but also allows the entire apparatus to be placed closer to the light, and this is therefore better utilized.

Application of the method in practice.

While in the foregoing I have dealt exclusively with the physical part of the method, I will now proceed to give a description of the application of the method in practice and an account of the therapeutic results achieved so far with its help.

As is evident from my first publication of this method 1. c. pp. 45-46, I was aware from the very beginning of the great development possibilities that lay in it, both with regard to its technique and with regard to its therapeutic area, and even though several of my assumptions and opinions have proven to be incorrect (e.g. I believed at the time that one could achieve an enormous amount by using very large lenses, which, as mentioned above, has proven not to be the case), it has nevertheless turned out, on the whole, that I have not been disappointed.

At that time (1896), I was — afraid that the method would be judged by the relatively good results achieved at that time, and I stated the following 1. c. p. 45: "A judgment on the method from the present standpoint will therefore be quite incorrect. Until experiments have been made with very bright light and the best possible apparatus, one will not be able to form any definite opinion about its real value." The question then becomes whether we have now reached that point, or at what point in time we reached that point, that the conditions set could be considered fulfilled. To this I would reply that I cannot consider the method to be even fairly fully developed before the introduction of the rock crystal apparatus and the large arc lamps of 60-70 Amp., which was not fully implemented until June 1898. The period before, that is, from November 1895 to June 1898, must be described, and I will describe it in the following, as the experimental stage. The separation of the experimental stage from the later stage is given by

its most important significance when it comes to the results of the treatment, while it plays virtually no role in the technique or execution of the treatment, which I will now discuss first.

Execution of the treatment.

No very significant changes have been made to the design, and the description I have given on 1. c. pp. 39-41 therefore fits quite well. The following changes have occurred.

Each area is now only treated for 5/4 hours instead of 2 hours, and yet the effect is now much stronger than it was previously after the two hours. This time (the 5/4 hour) is not an absolute, however, it is what we currently use for Lupus vulgaris, but it is very likely that experience will gradually show that the other diseases that are successfully treated by this method could either be satisfied with shorter or should have longer sessions. Possibly, in the case of Lupus vulgaris, too, one will gradually come to individualize the duration of the session, as there is a considerable individual difference in the strength of the skin reaction. At present, we individualize in such a way that the patients, according to their tolerance for the light, are placed either by the strongest or weakest lamps that we use, respectively 70 Amp. and 45 Amp., and that they sometimes have 2 sessions in a row at the same area.

At first I let each nurse look after only one patient, although I hoped later, when they became more experienced, to be able to let each nurse look after two patients; I tried this for a while, but gave it up again, as I felt that what was gained in economic terms was lost in the more inadequate care. And now, after the introduction of the long, thin rock crystal apparatus, which often has to be adjusted, and of the

The pressure glasses with water irrigation, I consider it very wrong, if the care of the Ptt. is to be satisfactory, to let one nurse care for more than one Pt. To this is added the circumstance that the nurses can rarely leave the pressure glass entirely to the elastic bands with which it is attached, but must hold it in the right position and often exert pressure on it with their fingers, which will be impossible when the person concerned is caring for two Ptt.

A greater difficulty than one would think has been connected with finding a suitable way of placing the PTT. You may think that this point is of such secondary interest that I could easily pass over it; but in reality it is of great practical importance that the treatment is not felt to be difficult and difficult by the patients. You will understand that it is often difficult to bring the various diseased areas, especially the face and neck, under the cone of light, so that the light falls more or less perpendicularly on them and so that the head is not turned into an uncomfortable position at the same time. Since a session lasts 5/4 of an hour, and one must keep the head in the same position during that time, it is of course important that it lies comfortably. This, quickly and easily placing the patient in a correct and comfortable position for the light, is one of the most important but also most difficult tasks of our nurses. The most practical has proven to be placing the PTT. on beds (of the type used in hospitals for dressings) with adjustable headboards. The finer adjustments of the head to bring the affected area under the focal point of the light cone are then made with the help of pillows of various shapes.

In many cases when the patient can be treated most easily in a sitting position or prefers to sit, we use rocking chairs to great advantage, as they can be adjusted with the help of wooden blocks that are inserted under the legs. One could probably 4

construct special chairs that would be even better and that would be adjustable in all directions, but they would be much more expensive and would hardly be useful in comparison.

The Effect of the Treatment.

Since phototherapy already covers a considerable number of skin diseases and is still bringing more and more under its control, the description of the treatment and its effects should have a general character. However, since our experience with lupus vulgaris is many times greater than with all the other diseases combined, I would prefer to give a detailed description of the treatment and the effects of this disease as a paradigm and then later, when discussing the other diseases, add if there is anything special to mention.

The treatment currently takes place in such a way that a small round spot (2-3 cm. in diameter) is illuminated for 5/4 hours every day. So that the nurses do not make a mistake about the location, and so that the light cone always aims precisely at the same spot, the doctor usually draws a ring around the spot to be treated with a dermatograph before the treatment begins. Since we have received the powerful rock crystal devices and the strong light, the same spot is usually not treated for several days in a row as before, provided that there is enough diseased tissue for one to choose another spot. The reaction is often so strong that it is not easy to do. However, there are great individual differences here, for while some of the patients who have such a small lupus that there is only room for one spot can tolerate treatment on it for many days in a row, others must take a break of one or more days between each treatment.

The visible effect of the treatment on the skin is a strong redness at the site, and the spot rises in level above

the surrounding skin; there often occurs, one might say most often, a vesicle formation at the site. The time of its appearance varies somewhat, from 16-24 hours after the illumination. This vesicle formation, which is sometimes of smaller, sometimes of larger dimensions, closely resembles the vesicles after vesicatories. Vesicator formation occurs much more frequently and strongly after electric light than after sunlight. Occasionally the reaction at the treated site is so strong that there is slight edema of the surrounding skin, especially if the spot is in the vicinity of the eyes. Incidentally, the size of the skin reaction can as a rule be considered as a measure of the strength of the apparatus and the light; if the reaction is very weak, there is reason to believe that there may have been something wrong with the lamp or the apparatus; in this way, as mentioned above, we have learned that the apparatus needs to be cleaned very often. Another practical interest of the reaction is that it can be used to check whether the nurse has been careful or not; if, for example, the spot is very blurred, or there are perhaps two red spots on the skin, this shows that the cone of light has not been kept in the same place during the entire session.

The further course of this skin reaction is that the vesicle dries up and forms a crust, which falls off after a few days, whereupon one sees the new epidermis formed over the entire extent of the spot. This relationship is constant. The phototherapy therefore does not cause any necrosis of the skin, and no scar tissue is formed or appears as a result of the treatment; the new epidermis is formed if vesicle formation has occurred simultaneously from the entire base of the spot. In my first dissertation 1. c. P. 41 I mentioned that I had seen necrosis a couple of times after phototherapy, but that this was due to a pure burn; I must add that we have only seen the same thing once later. However, when one considers that necrosis of the lupus tissue is something that

which is precisely what is intentionally caused by various earlier methods of treatment, it would be unreasonable to attribute any particularly unfortunate significance to these individual cases, which are as a rule caused by the patients' lack of adaptability, since they have not reported that the candle "burned".

I would like to add here that I have deliberately used this condition a couple of times as an experiment. These were isolated lupus nodules that had been very resistant to light treatment; I now suggested to the patients that we should try to burn them away with the light cone, that is, use the heat of the light at the same time as the chemical rays. By pressing hard with the pressure device, the process became less painful, and Ptt. endured it quite easily. But the result did not correspond to my expectations; on the contrary, the affection seemed to disappear and spread, and when one adds to this the painfulness of the treatment and the loss of substance with the formation of ulcers, then in reality I obtained through these experiments further proof of the great advantage of using "cold" light.

An important consequence of the property of light treatment that it does not cause scars and can therefore be used on healthy skin without harm is, as I mentioned at the beginning 1. c. p. 43, that one can treat the apparently healthy, but possibly infected surroundings of the diseased area. In this respect, light treatment has an invaluable advantage over many other methods, which could otherwise be rational.

After the diseased part and the surrounding healthy border have been thoroughly treated, a change in the diseased parts is evident; any ulcerations heal, the surface becomes firm and smooth, and diaphanoscopic examination shows that the characteristic lupus nodules become fewer and fewer, and finally disappear completely. The skin, however, remains

For some time the treated areas are red, but gradually become pale and acquire a natural color.

This transformation process naturally takes a certain amount of — time, how long is impossible to say, since there is such an extraordinarily large individual difference here, and a certain amount of time must therefore pass before one can really see the effect of the treatment and see whether the healing is complete or whether there are still diseased points remaining. For this reason, in order to save time and unnecessary treatment, we have arranged it in such a way that when the diseased areas have been treated thoroughly and have apparently improved a lot, the treatment is suspended for one or more months. During this time, as a rule, a clear differentiation occurs between the healed and the not yet healed parts; Pt. is now put under treatment again, but this time as a rule for a much shorter time, then again a break and then possibly a new treatment, until finally there is no more disease left. It is of course not so rare that Pt. is completely healed after the first treatment; but the rule is that more treatments are needed, which is also the intention. How these conditions have arisen with us, I will discuss below in my statistics. However, it goes without saying that such statistics can only be valid for a single clinic or a single doctor, since much depends on how long and how thoroughly the first treatment was carried out. That there are many patients who have had to repeat the treatment numerous times, you will also see from the statistics; but this is also the most unfavourable thing that can happen. The treatment works as reliably in lupus vulgaris as one could possibly expect. The fact that there are nevertheless a few among our more than 800 cases where the effect of the treatment has been very poor, can perhaps not be blamed so much on the method as on other random circumstances.

Since it was my concern to ensure that the experiments with this new method were so pure from the very beginning that they left no doubt, I used exclusively light treatment in the treatment of the first 130 patients. Later 1) in a few cases we have used other older methods of treatment with advantage prior to the light treatment, galvano-caustics, ointment treatment (especially Pyrogallus ointment), etc. and then continued and concluded with light treatment. How frequently we have used this combined method is evident from the statistics below. The cases in which we have used this initial treatment have been particularly cases with thick spongy granulation formations, with strongly pigmented thickened lupus areas and the like. It has been shown that such a preliminary treatment has considerably accelerated the healing in many cases, it has smoothed the way for the curative light treatment. The cases which are most difficult for light treatment to overcome are, according to the nature of the matter, namely, the very thick and deep-seated affections, and the very pigmented forms. I must also add that we have only used these strong agents as a preliminary treatment in cases where the cosmetic result could not be affected thereby, and where this was of less importance than a rapid healing (e.g. on the trunk or extremities).

In the last couple of years, after the introduction of the rock crystal apparatus, and after the effects on the skin have become stronger and the formation of vesicles more frequent, we have, in order to protect these excoriations caused by the treatment, allowed the patients to wear boric water compresses, which, incidentally, also has the effect of softening the crusts and thereby making them

1) After the spring of 1898, patient treatment was led by Dr. FORCHHAMMER as chief physician with Dr. REYN as permanent reserve physician.

diseased areas are better accessible for the light treatment. We also often use Diachylon and other healing ointments.[1])

(To be continued).

1) Since the above was printed (it has been ready for a long time) a large number of new lamps and new treatment devices have appeared. I have not been able to include them here, but will in the following go into more detail about them and a comparison between them and my own devices.

ON THE ABSORPTION OF ULTRAVIOLET RAYS BY BLUE LIQUIDS

VALDEMAR BIE

As described on pp. 18 and 19 of Prof. Finsen's preceding treatise, the patients were originally treated with electric light, which was concentrated through glass lenses and cooled by passing through a blue, ammoniacal solution of copper sulphate. At the same time that the rock crystal lenses were introduced, this blue solution was replaced by distilled water, because it was shown in some preliminary experiments that the blue liquid absorbed ultraviolet rays, so that the advantage of rock crystal lenses was lost. However, it was in these preliminary experiments. Since it is of course of great importance to know for sure whether the chemical effect of light is so much impaired by passage through a blue solution that electric light thus cooled is useless in practice, I have, at Prof. Finsen's request, made a couple of experiments to investigate this matter more closely.

The light from an arc lamp of 25 amperes and 50-48 volts was concentrated through a Finsens concentration apparatus with rock crystal lenses. Its front lens was 7 cm. in diameter and 11. cm. distant from the carbon tips. To the end of the concentration apparatus facing away from the lamp was attached a small stand, on which the rock crystal dishes with the bacteria mentioned below were placed, and on which a brass plate was suspended in a hinge to open and close the light.

The concentrated light passed through a light filter, either of rock crystal or of glass, and filled either with distilled water or with copper sulphate solution (1/2% solution, to which for every 10 cm^3. 1 cm^3. of ammonia water was added). Both light filters had 25 mm. lumen. The glass plates were 2.7 mm. thick, the rock crystal plates 1.7 mm. The front surface of the light filters was 40 mm. removed from the nearest lens of the concentration apparatus. The light cone had a diameter of 25 mm at this point.

After the light had passed through the light filter, it struck the bacteria, which had been treated in the following way: A broth culture of B. prodigiosus (in the first experiment 15 hours old, in the second 18 hours old) was filtered through filter paper. 1 — cm^3. of it was diluted with 9 cm^3. of water. Drops of this suspension were transferred onto rock crystal plates, which were set in a brass ring, so that the plate and ring together formed a dish. A drop was placed on each plate; this was dried in a desiccator with calcium chloride. The bacteria were then illuminated under the conditions indicated above. The rock crystal plate was placed 130 mm. from the nearest lens; at this point the light cone had a diameter of 12.5 mm. During the illumination, cold water was constantly flowing over the side of the rock crystal plate facing the light; the bacteria were placed on its opposite side. After the illumination, I covered the dried bacteria with a drop of agar. Finally, the dishes were placed with the bottom (rock crystal plate) facing up on moist filter paper in a Petri dish, so that they formed a moist chamber.

By the strong dilution with water and by drying, I have succeeded in avoiding the very considerable source of error represented by the absorption of chemical rays by the nutrient substrates, a source of error which is so great that it was absolutely necessary to avoid it.

When a salt solution or bacterial suspension or similar dries, a narrow, raised rim forms in

The periphery of the dried drop. If you cover this with a drop of agar, as I have done in these experiments, and let the bacteria grow out, the growth will be denser in this rim than inside it. If the bacteria are illuminated, they are killed first on the small surface inside the rim, but later in the rim. The destruction of the bacteria in this raised rim takes place, as was to be expected, irregularly. In reading the experimental results, I have therefore only taken into consideration the part of the dried drop that lies inside the rim.

I. Rock crystal light filter with distilled water.

	Try I	Experiment II
1 Sec.	Growth	
2 -	do.	
4 -	do.	Growth
7 -	No growth	No growth
10 -	do.	die.
15 -		do.
20 -		die.

II. Rock Crystal Light Filter with Copper Sulfate Solution.

	Try I	Experiment II
1/4 Min.	Growth	
1/2 -	do.	
1 -	do	Growth
2 -	do	do.
4 -	No growth	No growth
7 -		die.
10 -		die.

III. Glass Light Filter with Water.

	Try I	Experiment II
1/4 My.	Growth	
1/2 -	do.	Growth
1 -	do.	do.
2 -	No growth	No growth
4 -	do.	do.
6 -		do.

IV. Glass Light Filter with Copper Sulphate Solution.

	Try I	For increase II
1/4 My.	Growth	
1/2 -	do.	
1 -	do.	Growth
2 -	do.	do.
4 -	No growth	No growth
7 -		do.
10 -		do.

The result of the experiments is that the bacteria are killed under the given conditions:

when the light has passed through rock crystal and distilled water in 4-7 seconds;

when the light has passed through glass and distilled water at 1-2 My.;

when the light has passed through rock crystal and copper sulfate solution in 2-4 minutes;

when the light has passed through glass and copper sulfate solution for 2-4 minutes.

The considerable difference I have found, as the light has passed through rock crystal with distilled water or glass with distilled water, is due to the absorption of ultraviolet rays by the glass. The difference between glass with distilled water and glass with copper sulphate solution is due to the latter's absorption of blue and violet rays. I have found no difference between copper sulphate solution in rock crystal and in glass. In other words, a copper sulphate solution of the indicated strength absorbs so many chemical rays that the advantage of using rock crystal instead of glass is lost when the light passes through it.

STUDIES ON THE EFFECT OF LIGHT ON SMALLPOX VACCINE

OF

NIELS R. FINSEN AND GEORGES DREYER.

The great influence which light has on the course of the skin affection in smallpox cannot but arouse our astonishment. First, there is reason to wonder that ordinary daylight can have such a powerful effect that the mere exclusion of its chemical rays is sufficient to prevent the appearance of one of the most terrible disease states (the suppuration stage) known to us. Second, there is every reason for us in our bacteriological age to wonder that it is precisely the exclusion of a bactericidal agent which has this effect in an infectious disease. If one were to draw the following conclusion: since smallpox is an infectious disease, it would seem rational to let the patients lie in bright light and preferably in blue light, since this is particularly bactericidal, then from a purely theoretical point of view one would not be able to object greatly to this consideration.

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Such an objection has actually also been made to the treatment of smallpox by excluding the chemical rays of light. It was an English physician, Dr. MOIR, who in The Lancet [1])

[1]) JOHN MOIR. Treatment of small pox by exclusion of the chemical rays of daylight. *The Lancet* 29. Sept. 1894, p. 739.

against this treatment solely on the — without having tried it, wrote — basis of the above conclusion. Dr. M. ended his article with the words that in the treatment of smallpox it was precisely: "light, light, more light".

However, experience gained has greater value than theories, and they have not proved Dr. MOIR right. Besides, the method was far from lacking a theoretical justification, it only had the fault of not quite agreeing with the prevailing bacteriological views of the time. That it was correct is now shown by the rather numerous and quite constant results which have been achieved by "red light" treatment, and there is nothing to do but admit that in the case of smallpox the inflammatory effect of light is of far greater importance than its bactericidal effect.

There was, however, still the possibility that the pathogens of smallpox could react differently to the effects of light than other microorganisms; at least some studies [1]) carried out at the Vaccination Institute in Hanover seem to indicate this. These showed that if animal smallpox vaccine was enclosed in capillary tubes and then exposed to diffuse daylight or even sunlight for 2-8 weeks, the activity of the lymph nevertheless remained unchanged.

Since the solution of this question seemed to us to be of some interest, we have subjected it to renewed investigation.

EXPERIMENTAL DEVICE.

An electric arc lamp is used as the light source, and a Finsens concentration apparatus with lenses of rock crystal is used to concentrate the light.

1) Medical. extra. Mittheil. v. d. quay. Healthy County. Vol. 5, Issue 2, p. 94
*) The studies were carried out by G. DREYER.
3) Message from Finsen's medical institute. 1 1899 (Jan.) p. 54-80.

The diameter of the positive and negative carbon was 2.4 and 1.5 cm respectively. The tip of the positive carbon was always 11.5 cm. away from the nearest lens in the concentration apparatus. New carbon (same length) was inserted at the beginning of each series of experiments. For all experiments the arc lamp burned with 25 amperes and 49-50 volts. During the experiments the direction of the light was always 45° below the horizontal plane, and the illuminated surface was perpendicular to the direction of the beam.

The animal smallpox vaccine used for the illumination (usually glycerin emulsion) has been very willingly given to the Lighting Institute by the Royal Vaccination Institute, just as the latter has also very willingly undertaken the no small task of carrying out the vaccinations with the illuminated vaccine, which latter is of the greatest importance, as considerable routine is required to obtain a uniform and safe effect. For all the courtesy shown, we therefore ask the Vaccination Institute and its director, Mr. Corps Physician, Dr. med. Bondesen, to accept our best thanks.

The vaccine to be illuminated was placed as a drop on a flat rock crystal plate, set in a brass rim, with the help of a platinum wire ring of 3.5 mm diameter. (The thickness of the platinum wire was 0.9 mm). The greatest thickness of the drop in almost all experimental series was c. 0.4 mm, except for experimental series 1 and 2 (c. 0.3 mm) and experimental series 12 and 13 (c. 0.5 mm). The drops were always placed in the middle of the rock crystal plate, on the side facing away from the light source. During the illumination, the dishes were placed in such a way that the center of the rock crystal plate was centrally located in the part of the light cone that contained the most chemical rays (tested with silver paper). The diameter of the light cone was here c. 1. cm.

During the lighting, the dishes, which were not provided with a lid, were sprinkled with cold water to eliminate the effect of heat.

Where experiments have been carried out with clear, blue or red

Glass, in order to exclude certain parts of the spectrum, this is done in such a way that one of the mentioned glass plates is placed between the light source and the rock crystal plate. Both plates are sprinkled with cold water.

After the illumination, vaccination has been carried out from each drop on a child with 3 scratches on the left arm; on the right arm of the same child, in all cases, control vaccination has been carried out with unilluminated vaccine from the same glass tube as that used for the illumination. The control vaccinations on the right arm (also 3 superficial scratches) have in all cases resulted in the development of 3 vaccine pustules (1 for each scratch) of normal typical shape and size (5: strong impact), which makes these control vaccinations particularly suitable for use for comparison. The inspection of the vaccinated children has been carried out the week after the vaccination.

Vaccine from 11 different calves was used for the experiments. The age of the vaccine varied from 1-4 weeks.

The same series of experiments was always carried out on the same day with the same vaccine, and the individual experiments were carried out in immediate succession. The abbreviations used in the attached tables are as follows:

3 Vaccine pustules of normal size 2: strong impact.
3 — of less than normal C. 2: medium-strong attack.
3 — of small Size 2: weak Impact.
— 3 of insignificant Size 2: abortive Estimate.

Trial Series I: Vaccine from Calf 26. Age of the Vaccine: 15 days. Lighting by rock crystal. Maximum thickness of the drop c. 0.3mm. Inoculation of 9 children.

Forseg No.	Lighting time	Child No.	Number of Scratches	Result of the Inoculation
1	1 Sec.	1	3	Strong impact (3 pustules)
2	2 „	2	3	„ „ (3 P.)
3	3 „	3	3	„ „ (3 P.)
4	5 „	4	3	„ „ (3 P.)
5	10 „	5	3	medium A. (3 P.)
6	25 „	6	3	„ „ (3 P.)
7	50 „	7	3	abortive A. (3 P.)
8	100 „	8	3	no estimate
9	200 „	9	3	no estimate

Trial Series II: Vaccine from Calf 30. Age of the Vaccine: 15 days. Lighting gj. Rock crystal. Thickness drop c. 0.3mm. Inoculation of 9 children. The largest

Forseg No.	Lighting time	Child No.	Number of Scratches	Result of the Inoculation
1	1 Sec.	10	3	Strong impact (3 pustules)
2	2 „	11	3	„ „ (3 P.)
3	3"	12	3	„ „ (3 P.)
4	5 „	13	3	„ „ (3 P.)
5	10"	14	3	medium A. (3 P.)
6	25"	15	3	„ „ (3 P.)
7	50 woo	16	3	no estimate
8	100 „	17	3	no estimate
9	200"	18	3	no estimate

Trial series III: Vaccine from calf 37. Age of vaccine: 16 days. Lighting: rock crystal. Maximum thickness of the drop: c. 0.4 mm. Inoculation of 9 children.

Forseg No.	Lighting time	Child No.	Number of Scratches	Result of the Inoculation
1	50 Sec.	19	3	Medium Impact (2 Pustules)
2	50 „	20	3	„ „ (1 P.)
3	60 „	21	3	„ „ (3 P.)
4	60 „	22	3	„ „ (2 P.)
5	75"	23	3	weak A. (3 P.)
6	75 „	24	3	„ „ (3 P.)
7	100 „	25	3	abortive A. (1 P.)
8	100 „	26	3	abortive A. (1 P.)
9	100 „	27	3	abortive A. (1 P.)

Trial series IV: Vaccine from calf 37. Age of vaccine 23 days. Lighting by rock crystal and red glass. Maximum thickness of the drop c. 0.4 mm. Inoculation of 6 children.

Experiment No.	Exposure time		Child No.	Number of Scratches	Result of the Inoculation
	Rock crystal	Red Glass			
1	75 Sec.		28	3	weak impact (2 pustules)
2	100 „		29	3	medium A. (2 P.)
3	150"		30	3	weak A. (2 P.)
4	200 „		31	3	no estimate
5		15 minutes	32	3	strong A. (3 P.)
6		30 „	33	3	strongly A. (3 P.)

Trial series V: Vaccine from calf 37. Age of vaccine: 26 days. Lighting: rock crystal. Maximum thickness of the drop: c. 0.4 mm. Inoculation of 2 children.

Forseg No.	Lighting time	Child No.	Number of Scratches	Result of the Inoculation
1	120 Sek.	34	3	abortive stroke (1 pustule)
2	120 „	35	3	no estimate

Trial series VI: Vaccine from Calf 39. The vaccine Age: 10 days. Lighting: rock crystal. Maximum thickness of the droplet: c. 0.4 mm. Inoculation of 4 children.

Experiment No.	Lighting time	Child No.	Number of Scratches	Result of the Inoculation
1	100 Sec.	36	3	abortive stroke (1 pustule)
2	100 „	37	3	„ „ (1 P.)
3	200 „	38	3	no estimate
4	200 „	39	3	no estimate

Trial series VII: Vaccine from Calf 2. Vaccine Age: 16 days. Lighting: rock crystal, clear and blue glass. Maximum thickness of the drop: approx. Inoculation of 6 children.

Experiment No.	Exposure time			Child No.	Number of Scratches	Result of the Inoculation
	Rock crystal	clear Glass	blue glass			
1	200 Sec.			40	3	abortive stroke (1 pustule)
2	200 „			41	3	„ „ (1 P.)
3		5 min.		42	3	strongly A. (3 P.)
4		10 „		43	3	„ „ (3 P.)
5			5 Minutes	44	3	„ „ (3 P.)
6			10 „	45	3	„ „ (3 P.)

Trial series VIII: Vaccine from Calf 3. Vaccine Age: 9 days. Lighting: rock crystal, clear and blue glass. Maximum thickness of the drop: c. 0.4 mm. Inoculation of 10 children.

Forseg No.	Exposure time			Child No.	Number of Scratches	Result of the Inoculation
	Rock crystal	clear Glass	blue Glass			
1	200 Sec.			46	3	intel Estimate
2	200 „			47	3	no estimate
3		5 min.		48	3	strong A (3 Pustules)
4		5 „		49	3	„ „ (3 P.)
5		10 „		50	3	medium A. (3 P.)
6		10 „		51	3	„ „ (3 P.)
7			5 min.	52	3 strong A.	(3 P.)
8			5 „	53	3	„ „ (3 P.)
9			10 „	54	3	medium A. (2 P.)
10			10 „	55	3	„ „ (2 P.)

Trial series IX. Vaccine from calf 3. Age of vaccine: 16 days. Lighting: rock crystal. Maximum thickness of the drop: c. 0.4 mm. Inoculation of 8 children.

Forseg No.	Lighting time	Child No.	Number of Scratches	Result of the Inoculation
1	125 Sec.	56	3	no estimate
2	125 „	57	3	no estimate
3	150 „	58	3	no estimate
4	150 „	59	3	no estimate
5	175 „	60	3	intel Estimate
6	175 „	61	3	no estimate
7	200 „	62	3	no estimate
8	200 „	63	3	no estimate

Experimental series X. Vaccine from calf 4. Age of vaccine: 18 days. Lighting: rock crystal, clear and blue glass. Maximum thickness of the drop: c. 0.4 mm. Inoculation of 10 children.

Experiment No.	Exposure time			Child No.	Number of Scratches	Result of the Inoculation
	Rock crystal	clear Glass	blue glass			
1	200 Sec.			64	3	no estimate
2	200 „			65	3	abortive A. (1 Pustule)
3		15 minutes		66	3	weak A. (3 P.)
4		15 „		67	3	„ „ (2 P.)
5		20 „		68	3	no estimate
6		20 „		69	3	abortivt A. (1 P.)
7			15 minutes	70	3	no estimate
8			15 „	71	3	no estimate
9			20 „	72	3	no estimate
10			20"	73	3	no estimate

Trial series XI. Vaccine from calf 5. Age of vaccine: 21 days. Lighting: rock crystal. Maximum thickness of the drop: c. 0.4 mm. Inoculation of 12 children.

Forseg No.	Lighting time	Child No.	Number of Scratches	Result of the Inoculation
1	35 Sec.	74	3	Medium Impact (2 Pustules)
2	50 „	75	3	„ „ (2 P.)
3	65 „	76	3	„ „ (3 P.)
4	80 „	77	3	„ „ (3 P.)
5	95 „	78	3	„ „ (3 P.)
6	110"	79	3	„ „ (2 P.)
7	125 „	80	3	„ „ (3 P.)
8	140 „	81	3	no estimate
9	155 „	82	3	weak A. (2 P.)
10	170 „	83	3	„ „ (3 P.)
11	185 „	84	3	„ „ (2 P.)
12	200 „	85	3	no estimate

Trial series XII. Vaccine from calf 10. Age of vaccine: 5 days. Lighting: rock crystal, clear and blue glass. Maximum thickness of the drop c. 0.5 mm. Inoculation of 10 children.

Experiment No.	Exposure time			Child No.	Number of Scratches	Result of the Inoculation
	Rock crystal	clear Glass	blue glass			
1	200 Sec.			86	3	weak impact (1 pustule)
2	200 „			87	3	medium A. (1 P.)
3		15 minutes		88	3	strong A. (3 P.)
4		15 „		89	3	„ „ (3 P.)
5		20 wo		90	3	medium A. (2 P.)
6		20 „		91	3	„ „ (1 P.)
7			15 Minutes	92	3	„ „ (3 P.)
8			15 „	93	3	„ „ (3 P.)
9			20"	94	3	„ „ (2 P.)
10			20 „	95	3	„ „ (2 P.)

Trial Series XIII. Vaccine from Calf 7. Vaccine Age: 26 days. Lighting: rock crystal, clear, blue and red glass. Maximum thickness of the drop: c. 0.5 mm. Inoculation of 8 children.

Experiment No.	Exposure time				Child No.	Number of Scratches	Result of the Inoculation
	Rock crystal	clear Glass	blue glass	Red Glass			
1	150 S.				96	3	weak Impact (3 P.)
2	200 „				97	3	abortivt A. (1 P.)
3		15 minutes			98	3	strong A. (3 P.)
4		20 „			99	3	medium A. (1 P.)
5			15 minutes		100	3	„ „ (2 P.)
6			20 „		101	3	„ „ (3 P.)
7				20 minutes	102	3	strong A. (3 P.)
8				30 „	103	3	„ „ (3 P.)

The experimental tables show: That vaccine, illuminated under the above conditions through rock crystal, is not noticeably affected by illumination times of less than 10 seconds.

When illuminated for periods of 10-100 seconds, there is a clear weakening and sometimes complete destruction.

By illumination for times of 100-200 seconds, very strong weakening or total destruction occurs. An illumination time of 200 seconds can be considered, under the above-mentioned conditions, as an illumination time that almost certainly leads to total abolition of the vaccine's ability to produce vaccine pustules.

For comparison, it should only be noted that a Prodigiosus culture, dried on a c. 0.3 mm thick agar layer and illuminated through it under exactly the same conditions, is killed by c. 40 seconds of light exposure.

The experiments also show that slight variations in the thickness of the illuminated layer are of great importance. In series of experiments I and II it is seen that the vaccine is destroyed after illumination for 100 seconds, while in series of experiments XII and XIII even 200 seconds of illumination does not lead to absolute destruction; exactly similar conditions are also found when we exclude certain parts of the spectrum (series of experiments XII and XIII).

From series of experiments IV, VII, VIII, X, XII and XIII it appears that in the destruction of the vaccine, as also in the destruction of the bacteria, it is mainly the ultraviolet rays that act.

5 min. Illumination through clear or blue glass, which retains a large part of the ultraviolet rays, thus has absolutely no detectable effect. Only 10 min. illumination through clear or blue glass produces weakening, and an illumination time of 15-20 min. is required to produce strong weakening or destruction.

The relationship is even more clear when the lighting is passed through dark red glass, which retains all

chemical rays, since even 30 minutes of illumination does not affect the effectiveness of the vaccine to any detectable degree.

The slight variations that some experiments show are naturally explained by small differences in the experimental procedure, which are almost impossible to avoid, such as slight variations in brightness, drop thickness, etc.

It has not been possible to observe any difference in the effect of light on vaccines from different calves.

It has often been shown previously, [1]) that temperatures from 30°-40° have a weakening effect on smallpox vaccine and shorten the time it retains its ability to produce pustules; since it has now been shown here that strong light also has a very harmful effect, the same precautions must be observed when storing vaccines as with the known bacteria and their toxins, and therefore they must be stored in the cold and dark (possibly in red glass).

1) Lemoine: Compt. clear de la Soc. they Biology. No. 12. p. 321.

ON THE PRODUCTION OF ARC LIGHT BY THE USE OF COOLED ELECTRODES.

OF

SOPHUS BANG.

After FINSEN demonstrated the usefulness of the "chemical" rays of light for therapeutic purposes, a number of attempts have been made, both here at home and abroad, to produce such rays in larger quantities or in a cheaper way than hitherto. These attempts have partly aimed at utilizing the ordinary carbon arc light in ways other than that used by FINSEN, and partly attempts have been made to use or produce new light sources with a greater wealth of chemical rays. It is only these latter efforts that I shall briefly mention here.

Since many metal spectra contain a great wealth of short-wavelength, i.e. strongly chemically active rays, it is reasonable that attention has been mainly directed to these. Thus FINSEN describes as early as 1896') an experiment which he carried out in this direction, following the suggestion of Prof. LA COUR, using calcium in such a way that a mixture of lime and graphite was placed in a borehole in the positive electrode, which as usual consisted of coal. The light thus produced proved to be very rich in chemically active rays, but the experimental results were not available at that time.

1) "On the Use in Medicine of Concentrated Chemical Rays", p. 47.

for practical use, essentially because the glass collecting apparatus then used made the usefulness of the ultraviolet rays produced illusory. A year later I tried to use magnesium, partly as a metal, partly in various compounds; in this way too the richness of the light in ultraviolet rays can be increased; but its use has not been attempted in practice. A wick of zinc in coals has been used by MAGNUS MØLLER[1]) for his experiments on ultraviolet rays. Later, STREBEL) has suggested the use of aluminum oxide and silicate, as well as zirconium, in addition to the substances mentioned. Furthermore, he has used electrodes of metallic cadmium, aluminum and zinc, as he allowed high-voltage induction sparks to jump between poles of these metals; in this way he obtained a light that was extraordinarily rich in ultraviolet rays. An experiment with mercury as the positive pole and carbon as the negative, using direct current, was carried out in the winter of 1900-1901 at Finsen's Light Institute by KJELDSEN, using ARON'S and HEWITT'S mercury lamps as a starting point. By this method too, a light was obtained which was extraordinarily rich in ultraviolet rays.

A metal which, because of its great wealth of spectral lines, would seem particularly inviting to experiments is iron. This has been used in an electric lamp for therapeutic use by the Russian physician EWALD[3]), who in 1895 believed to have made the assumption that the workers in the ironworks in Kolomna (Moscow Governorate) who were employed in welding iron together with the help of electric current were protected from certain diseases, such as rheumatism. He

[1]) MAGNUS MØLLER: Der Einfluss des Lichtes auf die Haut etc. Stuttgart 1900.

[2]) Deutsche med. Wochenschrift, No. 5-6, 1901.

[3]) See KERNIG: Erfahrungen über die Einwirkungen intensiveven elektrischen Lichtes. Zeitschr. f. diet u. phys. Therapy. 1899, Vol. 2, p. 238.

therefore constructed a lamp, the positive pole of which consisted of cast iron, the negative of a carbon rod; a current of 2-300 amperes was used. The Ewald lamp was later used by KOSLOFFSKI in a private clinic in St. Petersburg. The patients had to be placed 11/2 meters away from the arc, as the radiation from the melting iron at a shorter distance was unbearable. The parts of the patient that were not to be treated were protected by screens. The sessions lasted for 2 minutes and were followed by skin erythema.

The use of metals as high-current electrodes is, however, associated with a number of practical difficulties, as the metal melts and spatters, so that the patient must be placed at a great distance from the light source, and the regulation of the lamp is thereby made difficult. In May 1901 I came up with the idea of cooling the electrodes with the help of water in order to avoid these disadvantages. I had acquired an X-ray lamp with a water-cooled anticathode for the use of the Light Institute; it was then natural to try water cooling also with ordinary direct-current electrodes. By forming an arc between two iron tubes through which water flowed, it turned out that a calmly burning arc light with the characteristics mentioned below was obtained.

Furthermore, a closer examination of the literature revealed that W. SIEMENS had already used a water-cooled metal electrode in an arc lamp in 1879. While the positive pole in this consisted of carbon, the negative pole was formed by a gilded metal capsule, the interior of which was cooled by a water stream. This ensured that the electrode was only slightly corroded, which was a necessary link in the regulation mechanism of the lamp in question; on the other hand, a change in the properties of the light was not intended by this cooling; as I will discuss in more detail below, it is also especially by cooling the positive electrode that the light changes character.

The cooling of the electrodes can be done in several different ways. At lower currents (below 20 amps) I have so far generally preferred internal cooling, in such a way that the metal in question is shaped like a cap that can be screwed onto a double-walled tube with water circulation. At higher currents it is, at least for the positive pole, more practical to use external cooling, in such a way that the electrode is placed in a vessel with flowing water, so that only its tip protrudes above the water; in some cases it is advantageous to place the electrode tip right in the water crust or even a millimeter below it, which certainly changes the spectral character of the light, but does not prevent the arc formation. Under all circumstances the coolant must act on the electrode very close to the pole surface; for iron the distance must not be more than 3 mm; for metals with better thermal conductivity, e.g. Silver, the distance can be somewhat greater.

The most striking effect of the cooling is observed in the case of the positive electrode, as the "cratering", which is characteristic of this, is suppressed or at least reduced to a minimum. This is most clearly seen in the use of cooled carbon; as the thermal transition effect at the positive pole surface is suppressed, the carbon, instead of crater-shaped, becomes convex, but with small flat facets as an expression of the fact that there is still some local effect of the current at the place where the arc emanates from the pole. If cooled iron is used as the positive pole, the metal is consumed relatively slowly, as it disappears in the form of iron nitride; this decline is so slow, however, that an automatic regulation of the length of the arc has been dispensed with in the forms of lamps according to this principle that have been tried so far. If poles of less easily oxidizable metals, such as silver, are used, the pole is consumed only extremely slowly.

In connection with the fact that crater formation is so greatly reduced, it is stated that the heat radiation is relatively small. At currents of up to 10-12 amperes one can thus touch the electrode a few millimeters from the arc without feeling pain, and one can hold one's hand for a longer time at a distance of a few centimeters from the arc without discomfort. At a distance of 5 cm from an 8 ampere iron lamp, a blackened thermometer thus did not rise above 40° in repeated experiments. In an ordinary carbon arc light, the majority of both the luminous and the warming rays emanate from the glowing crater; this light is thus in reality for the most part an "incandescent light"; the light emanating from cooled metal electrodes, on the other hand, is predominantly a real arc light, since the electrodes only glow on the relatively small surfaces where the arc emanates from them. As a result, the character of the light is largely determined by the vapor spectrum of the electrode metal in question.

So far I have mostly investigated the light from cooled iron electrodes. Since the iron spectrum is so rich in ultraviolet lines, this circumstance determines both the properties of this light and its applicability. The properties that are of most interest when it comes to its applicability to skin disorders are its skin-irritating and bactericidal ability, as well as how deeply it is able to penetrate the tissues. As for the ability of iron light to induce a light reaction on the skin, this is extraordinarily great. A few minutes' stay at a distance of 1 meter from a 25 ampere iron lamp is able to induce a light rhythm in the facial skin. If the skin on the volar side of the forearm is exposed, for example, for 10 seconds of this light at a distance of 12 cm., an erythema arises, which is characterized as lyserythema in that it does not appear until a few hours after the irradiation, and in that it leaves pigmentation. The bactericidal properties of the light are related to this. While an ordinary

A carbon arc lamp of 30 amperes and 50 volts at the most favorable angle of radiation kills Staph. 1) pyog. aur. in 3-41/2 minutes in surface culture, a similar effect is achieved by a 25 ampere iron lamp in about 5 seconds (the time determined by illuminating through a suitable section in a rapidly rotating disk).

A peculiarity of ultraviolet rays is that they are absorbed so strongly by most substances, and in general the stronger the further out into the ultraviolet part of the spectrum they are. At wavelengths below λ = 2000 they are even absorbed strongly by water, and even by air. Glass is only fairly permeable to that part of the ultraviolet rays which lies closest to the violet part of the spectrum. In accordance with this, it has been shown that an ordinary object glass about 2 mm thick protected the skin completely against the influence of the iron light, which without the glass would have given a strong reaction with the formation of a bulla. The ultraviolet rays penetrate the skin even more difficultly. Thus STREBEL found that concentrated ultraviolet light could not pass a human ear compressed between quartz plates. In another experiment, a piece of skin, which had been prepared free of fat, was clamped between two quartz plates and "under exclusion of all color rays, illuminated with concentrated ultraviolet light originating from induction sparks between zinc and aluminum electrodes"; the irradiated object was 140 cm. from the spark; a faint but very distinct glow of light appeared on a fluorescence screen placed behind the skin. FREUND) investigated the absorption conditions in the epidermis, placing pieces of burn blisters, pemphigus blisters and Thiersch's epidermal patches in front of it.

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1) There is talk here about the "relative" murder limit. See the following treatise. *) Archiv f. Derm. u. Syph. Heft 1, 1901.

0.9 mm wide slit in a Rowland's grating spectroscope. As a light source he used the spark amplified by Leyden jars from a powerful Ruhmkorff inductor with electrodes of the EDER alloy (lead, zinc and cadmium) at a distance of 40 cm. from the slit. FREUND came to the same result for all 3 preparations examined; he found that, apart from the cadmium line λ = 3250 Å. E., ultraviolet light after an illumination time of 15 minutes did not pass through the pieces of epidermis in such quantity that they could affect the photographic plate; for the larger wave-widths, on the other hand, a certain quantity of the light passed through.

These experiments, which are interesting in themselves, do not provide any quantitative information, since one would have to know the energy distribution within the relevant spectrum, but one can probably draw the conclusion, which is also probable at first glance, that the ultraviolet rays that are closest to the violet rays penetrate the epidermis relatively better than those that are further out in the ultraviolet.

In order to obtain a preliminary idea of the distribution of the bactericidal rays in the spectrum of iron, I let light from a 25 ampere iron lamp pass through a spectral apparatus with lenses and prisms of quartz. As the spectrum thus formed lies in a line which forms a very acute angle with the rays emerging from the prism, I renounced examining the spectrum at the place where it was completely clean, but placed a surface culture of B. prodigiosus perpendicular to the direction of the rays at a suitable distance behind the prism, where the spectrum was sufficiently differentiated for my purpose. At this place the visible spectrum had an extension of 10 mm, while the ultraviolet, collected on uranium glass, had a length of c. 50 mm. It now appeared that with an illumination of 3-4 minutes the bacteria were killed in a

6-7mm wide stripe, the centre of which lay c. 15mm outside the outermost visible violet, while in the entire visible part of the spectrum and in the nearest 10mm of the ultraviolet no effect was visible. At an illumination time 3 times as long the bacteria were killed or weakened to an extent of c. 40mm in the ultraviolet spectrum, but even with this illumination they remained unaffected in the entire visible spectrum and the part of the ultraviolet closest to it. The rays which act most strongly on silver paper, as well as those which produce the strongest fluorescence in uranium glass, were found to be distributed in a similar manner. Presumably the agreement between these conditions is due to a corresponding distribution of the amount of energy in the short-wave part of the iron spectrum; however, this can only be determined with the help of bolometric investigations.

This much is already clear from these experiments, however, that those of the iron light rays which have the strongest effect on bacteria lie rather far out in the ultraviolet. This is in good agreement with the fact that the active parts of the iron light undergo a very strong absorption in the skin. Through a 1 mm thick, fat-free layer of skin (originating from the chest of a c. 12-year-old child), silver chloride paper is affected c. 3 times more slowly by the light from a 25 ampere iron lamp than it was at the same distance and under otherwise equal conditions by a 25 ampere carbon arc lamp. It is probably the visible rays also contained in the iron arc light that have caused the slight darkening of the paper which gradually occurred. Through a 0.1 mm thick layer of the same skin on the epidermis side (microtome section of frozen preparation), on the other hand, the silver paper was affected by the two types of light approximately equally quickly; this thin layer has evidently been able to penetrate some of the ultraviolet rays. That they are able to penetrate through

The epidermis also appears from the strong cardiac dilation they induce.

The properties of iron light, as far as we know them so far, are the following: Relatively little heat radiation; strong skin-irritating effect; strong bactericidal effect; very little penetration ability. The possibility of using this light clinically must be assumed to be linked to these properties. Where a superficial bactericidal and skin-irritating effect is desired, it must be able to find a field of action; it is not suitable for all deep-seated disorders, such as, for example, lupus vulgaris.

For preliminary clinical experiments I have made a small hand lamp for 8 to 10 amperes and 40 volts; it is intended to be applied in toto to the diseased area, so that the arc comes a couple of centimeters from the skin; it is provided with pressure quartz according to the Finsen pattern. The small thimble-shaped iron electrodes must be renewed when the lamp has burned for 3 to 4 hours, as they gradually oxidize and disappear as a smoke of iron oxide. One disadvantage is that this smoke regularly settles on the pressure quartz, which therefore has to be wiped off frequently. With this lamp, one can induce a typical light reaction with bulla formation after 3-5 minutes of illumination. Nothing definite can be said about the duration of possible therapeutic sessions; just as little can be stated as yet about specific indications for its use.

A direct comparison between the reactions produced by this small lamp and those produced by the use of Finsen's apparatus would be misleading; for as the light from the latter contains a large quantity of the rays which penetrate into the depth, the difference in the reactions produced by the use of the two kinds of apparatus is not merely quantitative, but qualitative. The hand lamp should

probably considered from the point of view that where an intense but superficial effect is desired, it provides such a means in a considerably cheaper way than has hitherto been possible; where a deep effect is necessary, it should not be used at all.

ON THE EFFECTS OF LIGHT ON MICROBES.

II. AN IMPROVED METHOD OF INVESTIGATION.

OF

SOPHUS BANG.

In a previous work[1]) I have drawn attention to how necessary it is in studies of the bactericidal effect of light to take into account that the nutrient in which the bacteria are located under the illumination absorbs a substantial part of the light used. The BUCHNER method, improved by FINSEN, is the most accurate of those used so far. However, when it comes to determining the killing time of the bacteria accurately, the objection can be made to this method that it illuminates the bacteria distributed in an agar layer, namely as a spread culture. Under these conditions, the bacteria lying in the depths of the agar are not reached by the light until it has been filtered through a more or less thick layer of the agar, which, like most other nutrient media, due to its yellowish color and other spectroscopic properties, absorbs to a particular extent the short-wave rays, that is, precisely those that are most effective against microbes. Small changes in the thickness, color and other properties of the nutrient can therefore have an influence on the time that the light must act to kill the bacteria. For

1) S. BANG: On the Effects of Light on Microbes. I. Messages from the Finsen Medical Light Institute II. Copenhagen. 1899.

To reduce this unpredictable light absorption as much as possible, I used "hanging drops" of a maximum thickness of 0.05-0.15 mm in the work mentioned. The light absorption of the nutrient was not completely eliminated, but was nevertheless reduced to a relatively small value, and a uniform effect of the surrounding air was also possible. Since a number of other physical factors were also taken into account, it was possible to obtain fairly constant experimental results, which was difficult with the older methods. It also turned out that the bacteria were killed in a much shorter time than one would have expected from the previous results. This is easily understandable; the microbes lying in the depth of a light-absorbing agar layer can withstand a longer period of illumination than those lying closest to the surface.

Dr. V. BIE has gone a step further in the direction of eliminating the light absorption of the nutrient by using surface cultures on agar, prepared in such a way that a few drops of the bacterial culture in question are spread on the nutrient substrate solidified in a Petri dish; using a desiccator with calcium chloride and air dilution, the culture liquid is dried as an even layer; when the surface thus prepared is now exposed to the light, this has no extraneous substances of any importance to pass through before it hits the bodies of the bacteria.

Since this procedure is, however, somewhat cumbersome, and since such an energetic drying process is in any case unlikely to have an effect on the vitality of several bacteria, I simplified the method in such a way that, with the aid of a fine cotton swab (an iron wire wrapped in fine hydrophilic cotton, sterilized in a test tube), I spread the bacterial culture as uniformly as possible on the agar plate, which is then left to dry spontaneously. My assistant, Dr. JANSEN, has recently used, instead of the cotton swab,

used a platinum eyelet; this achieves, on the one hand, that one is somewhat aware of how large a quantity of the culture is sown, and on the other hand, the surface dries even more quickly in this way by itself, already in 2-3 minutes. By "drying" here is understood only that there is no free, mobile liquid on the surface; the agar itself retains its moist consistency and is stored during and after the experiment in an atmosphere saturated with moisture (see below). One cannot completely deny the possibility that this method can have any influence on the resistance of the bacteria, especially when it comes to species that are particularly sensitive to drying out. But as long as one does not do experiments with such species, and as long as one is only talking about similar experiments with one and the same bacterial species, this circumstance will not play any demonstrable role.

That the bacteria really remain on the surface of the agar without penetrating into it can be confirmed, on the one hand, when they have later grown so far that the colonies can be seen with the naked eye, which, at least in the case of the bacteria examined so far, remain completely superficial; on the other hand, in the case of the tubercle bacillus, by hardening a plate so inoculated and making vertical microtome sections through it, I have directly convinced myself that the bacilli lay in a thin, even layer on the surface, without it being possible to see anywhere that a bacillus had penetrated through the surface of the agar layer.

The illumination of the surface cultures can be carried out in various ways; it is practical, especially time-saving, to use stepwise illumination. This method was used in 1893 by WARD [1]), who illuminated spread cultures in

[1]) MARSHALL WARD: Further experiments on the action af light on Bacillus anthracis and on the Bacteria of the Thames. Proc. of the Royal Soc. of London, Vol. LVI, 1894.

Agar through square or circular "windows", which were covered one by one under the illumination. A similar method was used by FINSEN, independently of WARD, in his first experiments on the bactericidal effects of light[1]), in that, in addition to the method published at that time, he also used the following, which he himself describes as follows: "Plate cultures in a Nielsen bottle were exposed to the light in such a way that after 1 minute a small field of the plate culture was covered with a piece of paper, after 2 minutes a new field was covered, after 3 minutes a third field, etc. The pieces of paper, which were glued with fish glue, were black on the side facing the bottle, to prevent the light from penetrating, and white on the side facing the light, to prevent the heat from acting. Numbers were written on the white side to indicate the time the underlying field had been exposed to the light. When the bacteria had grown out and the pieces of paper were removed, it showed A mosaic was formed, produced by the different effects of the different fields, and one could now read how long the light had taken to kill the bacteria. Later the method was modified in such a way that the entire surface of the bottle was covered with the same kind of paper, in which a number of round holes had been cut out; after the bottle had been exposed to the light, the individual holes were now covered in sequence and at certain intervals; in this way the effect of the light appeared sharper, as each field was now surrounded by a culture completely unaffected by the light, while the surroundings thus simultaneously served as a control. These methods were used for unconcentrated light."

I have combined the use of Step Lighting with

1) FINSEN: On the Use in Medicine of Concentrated Chemical Light Rays. 1896. P. 28-32.

The use of the surface cultures mentioned in this way is that I let a flat "shadow generator" advance step by step past the culture at certain intervals. Instead of, as is usually the case, illuminating one preparation for, say, 1 minute, another preparation for 2 minutes, etc., I illuminate a larger area of the surface culture for 1 minute, then let the shadow generator advance one step, whereby a corresponding strip of the culture is protected from the light; after a minute has elapsed, it is advanced a new step, so that now a total of two strips A B G lie in darkness, etc. While the first method for finding the effect of 1 to 10 minutes of illumination d j D requires 1 + M P 2+3...+10 min. = 55 min., in addition to the preparations for the individual experiments, the same series of experiments in the other only 10 minutes in total, and only preparations as for 1 experiment. In addition, it is of course easier to keep the light source constant for 10 minutes than for 55.

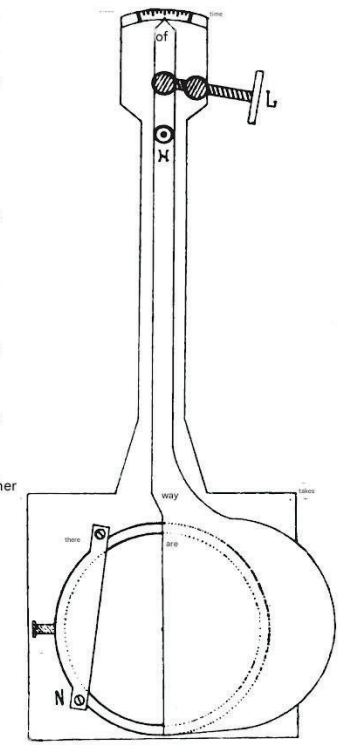

Fig. 1.

The accompanying schematic drawing shows the arrangement of the apparatus in which the illumination takes place. The brass plate ABCDEF has a circular cutout MNOQP, which is closed with a plane-parallel quartz disc, behind which the surface culture is

The shadow generator OKJ consists of a thin brass plate with a long stem JG, which can be turned around the pin H by means of the screw L. This moves the shadow generator so that its edge OP moves to the right or to the left immediately in front of the quartz disc R. The amount of the displacement is read by means of the pointer G. When the shadow generator is moved as far to the left as it can go, the edge OP touches the small shades a part of the quartz disc; the corresponding part of the culture thus serves for control. When the shadow generator is moved as far to the right as possible, it shades another part of the quartz disc at Q, also for control. At Uses a tube is used through which gases, the effect of which is to be investigated, can be introduced to the surface of the culture (a similar one is found next to Q).

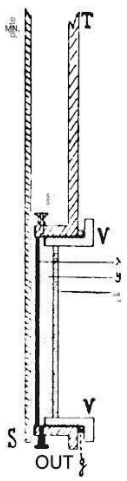

Fig. 2.

Fig. 2 shows a vertical sagittal section through the lower part of the apparatus. TT is the brass plate on which the whole is mounted. SS is the shadow generator. At X is the quartz plate. VV is a circular dish in which the agar plate (y) sown with the surface culture rests on a glass plate. At UU are the tubes through which various types of gas can be supplied. The culture dish VV is screwed into the apparatus and is provided with a rubber ring (g) to make it airtight and watertight.

In general, the whole apparatus is placed in a "photo-kteinometer" of the construction described in my work above. As I have made a slight change to this for a special purpose, I give a sketch of it in Fig. 3, referring to the details in the description given. The tin box ABCDE is placed in front of

The light source L is so placed that the light rays strike its front surface at a right angle (when it is a common electric arc lamp, the box is best placed at an angle of 50° to the axis of the coals). The box is normally filled with boiled distilled water, which is kept at a constant temperature by means of the lead tubes RR through which the water flows and the stirrer P. The shadow-giving apparatus

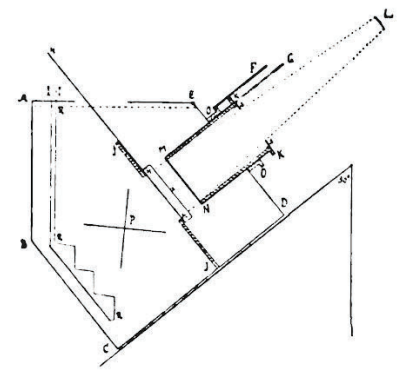
Fig. 3.

HHH is placed in the scenes J.J. The light enters the box through the quartz window MN, passes the plane-parallel liquid layer between this and HH, and finally reaches the surface culture through the quartz window X (see also Fig. 2).

The only obstacle that the light ray encounters on its way from the light source to the bacteria is, apart from the air, the two flat quartz plates and the flat liquid layer lying between them. In order to be able to vary its thickness in a certain way, the front quartz pane, MN, is placed at the end of a tube KNMK, which can be screwed in and out of the ring OO. The thickness of the liquid layer can be read on the scale F. At ss, a diaphragm can be inserted if necessary to prevent the reflection of light from the sides of the tube, which, like the rest,

Everything inside the box is matte black. The lid is used to open and close the light.

In order to be able to compare different research results with a common standard, I have provisionally and purely arbitrarily determined the following experimental conditions as "normal experiments".

An electric direct current arc lamp of 30 Amperes and 50 Volts is used as a light source; by means of insertable incandescent lamps the current intensity is regulated with an accuracy of at least 0.1 Amperes. The positive carbon has a diameter of 24 mm., the negative of 15 mm. (One of the difficulties in reproducing the same brightness at all times by means of such a lamp lies in the fact that the nature of the carbon can vary. By means of projection images of the arc in different directions one ensures that the crater burns with a regular shape. The "photoctinometer" is set up so that the rays which strike the centre of the quartz window form an angle of 50° with the axis of the carbon. The distance between the nearest point of the crater and the surface culture is 60 cm., which corresponds to a distance of 60 cm. without a water layer, since this is 2 cm. thick [1]).

As a test bacterium I have so far used Staphylococcus pyogenes aureus in a 20-hour broth culture, grown at 37°. It is filtered through ordinary, sterile filter paper and then diluted with 2 parts sterile broth. Of the broth thus diluted, which to the naked eye has a cloudy appearance, a suitable amount is transferred in the manner described with a cotton swab or platinum eyelet to the surface of a sterile agar plate, which has preferably been embedded in the culture dish a couple of hours beforehand. As soon as the liquid layer has dried sufficiently, the dish is screwed into the shadow-giving apparatus, and this is placed in the "photoctinometer", which should preferably contain liquid of at least 28°, thereby most certainly preventing fogging on the quartz window. After the gradual illumination has taken place, the removed culture dish is placed in a Petri dish lined with moist filter paper, which is placed in the thermostat, preferably at c. 34°, at which temperature it is easiest to avoid so much condensation forming that it can drip from the lid of the Petri dish onto the surface culture.

After 24 hours of standing, the culture has an appearance like Example Fig. 4, which is reproduced from a photograph.

1) See the cited work, p. 15.

To the right and left are two crescent-shaped areas with strong, confluent bacterial growth; these are the unilluminated control areas; between these areas 10 stripes have received 1 to 10 minutes of illumination respectively. In order to be able to read the location of these stripes conveniently, a glass plate on which are drawn sub-lines, corresponding to the individual displacements of the shader, is held in front of the (surface culture). The stripe furthest to the left has received 1 minute of illumination. A weak light effect is already evident here in that the stripe can be seen at all

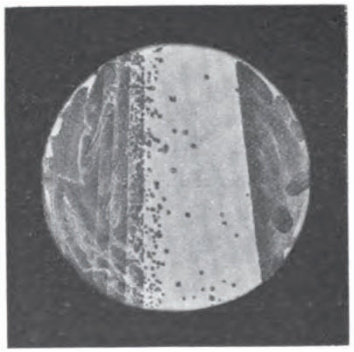

Fig 4.

distinguished from its surroundings; an even slightly stronger effect is seen in the next strip, which has received 2 minutes. In the 3rd strip (3 minutes of light) there is a noticeable thinning, and in the 4th strip (4 minutes) the number of colonies is so small that one can count the individual colonies (c. 50). In the 6th strip there are 11 colonies, in the 7th 5, in the 8th 4, in the 9th 4 and in the last strip, which has been illuminated for 10 minutes, there is only 1 colony. So we have not yet reached the absolute killing limit after 10 minutes of illumination (by which I understand the point at which even the most resistant individuals are killed; this is seen from another experiment (Fig. 5).

Here 12 stripes are illuminated in such a way that the one furthest to the left has had 6 minutes, the next 7, and so on until the 12th stripe, which has been illuminated for 17 minutes. The number of colonies in the individual stripes is respectively c. 10, 11, 2, 6, 4, 2, 3, 2, 0, 0, 0, 0. So, from the 14th minute onwards the absolute killing limit seems to have been reached. However, it is only quite approximately and with reservations that one can after such a

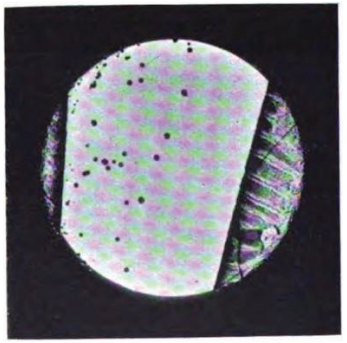

Fig. 5.

Experiments can set the absolute killing limit at 14 minutes; for where this limit will lie obviously depends, among other things, on the number of bacteria sown per square unit. An apparently sharper limit is seen after 4 minutes of illumination (Fig. 4), where the number of colonies has become "countable", while the colonies in the preceding stripes are so numerous that they flow together. The location of this limit, which I will call "the relative killing limit", for the sake of brevity, also appears to depend on how many bacterial individuals have been sown per square unit of the agar surface. This can be shown by making the following

search with different dilutions of the same culture, such as in the following series of experiments:

		Tribal culture.	Dilution 1:3	Dilution 1:9	Dilution 1:18	Dilution 1:36
Lighting 3	My.	Weak Thinning	Weak Thinning Strong	Strong Thinning c. 50Ko l.	c. 50 Col.	Strong Thinning c. 50 Col.
—	$3^1/_2$ -				22 -	
—	4 -	Strong Thinning c. 50 Col.	Thinning c. 50 Col.	10 -	8 -	5 -
—	5 -	30 -	12 -	1 -	0 -	4 -
—	6 -	16 -	4 -	0 -	2 -	3 -
—	8 -	2 -	4 -	2 -	3 -	0 -
—	10 -	2 -	1 -	0 -	1 -	0 -

We therefore find no sharp killing limit for cultures of Staph. pyog. aur. The conditions here are quite similar to those which I have previously demonstrated for B. prodigiosus by means of the drop method, namely an increasing dilution with increasing light exposure. In these, as well as in a whole series of bacteria examined later, it has been consistently shown within certain limits that the longer the exposure to light, the lower the percentage of bacteria that is able to resist it. But it seems that this "dilution curve" has a different location and perhaps also a different form in the different species of bacteria, as an expression of the different way in which the unequal resistance of the individuals to light is expressed in the different species. I shall not, however, go into these conditions in more detail here, as they are currently being made the subject of special investigations.

On this occasion I only wish to illustrate the applicability of the method for "biological light measurement", that is, for determining the relative ratio between the richness of different light sources in bactericidal rays or light-

permeability of filters for such. It has now been shown that for many practical studies of this kind one can use the location of the mentioned "relative killing limit", i.e. the place in the culture where the bacterial colonies from having been "innumerable" have become "countable" (c. 50-100). In 11 experiments, carried out with Staph. pyog. aur. in the described "normal" method, this limit was at 4.31/2 4.31/2, 3.4, 31/2, 41/2, 41/2 minutes, on average, i.e. about

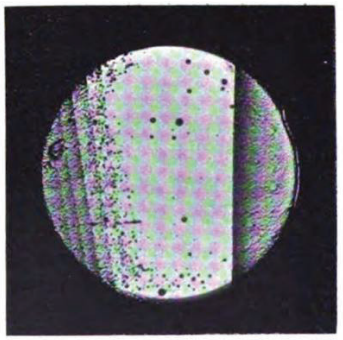

Fig. 6.

trained at 33/4 minutes, with a margin of 3/4 minutes or 20% on either side. This applies when the experiments are made at different times; the lack of more exact agreement is due to the difficulty of obtaining uniform cultures. Much greater accuracy can, as I shall return to below, be obtained by comparative experiments carried out simultaneously or immediately after each other with one and the same bacterial culture.

However, the aforementioned accuracy of c. 20% is already sufficient for many practical investigations, as it is often enough to obtain approximate values, among other things because the different light sources that are to be compared are often so different that they are difficult to compare.

equally different from each other in brightness. I will mention a couple of examples of this. While a 30 ampere carbon arc lamp at a distance of 60 cm., as mentioned, shows "relative killing" on average at 33/4 minutes, the same effect was obtained at the same distance in about 4 seconds by means of an arc lamp with the same current strength, but whose positive pole consisted of a water-cooled iron rod. Direct sunlight took on August 21, 1901, at 11-2 (in Copenhagen) over an hour to produce the same effect (see Fig. 6, where the shader has been moved every quarter of an hour, so that the shortest illumination is 1/4 hour, the longest 3 hours).

As an example of the greater accuracy when comparative experiments are made with one and the same bacterial culture, I can mention that in repeated experiments (a total of 6) it has still been possible to demonstrate the difference in the absorption that the light undergoes, whether it passes, for example, 2 cm. of distilled water or an equally thick layer of ordinary water. While the relative killing limit, when the tube KMNK (Fig. 3) was screwed in so far that the light only had 1/2 cm. of distilled water to pass, was found at 31/9 minutes, it was, on the other hand,

	12 cm. distilled water	1/2 cm. plain water	3 cm. distilled water	3 cm. regular. Water
Lighting 3 Min.	strong Ext.	weak Ext.	weak Ext.	Hint
— $3^1/_2$ -	c. 50 Colon.	Thinning	Thinning	weak Ext.
— 4 -	15 —	strong Ext.	strong Ext.	Thinning
— $4^1/_2$ -	8 —	strong Ext.	c. 50 Col.	strong Ext.
— 5 -	7 —	c. 50 Col.	28 -	strong Ext.
— $5^1/_2$ -	0 —	30 -	10 -	c. 50 Col.
— 6 -	0 —	20 -	3 -	?

when the apparatus was filled with ordinary water, at 5 minutes. When the thickness of the water layer was 3 cm., distilled water was obtained.

a Killing limit at 41/2 Min., for ordinary water at 51/8 Min.

From this we can see how important it can be to use the clearest possible water in the light filters of the therapeutic apparatus. And it will not be surprising that the light absorption that takes place in the commonly used nutrient substrates can reach a very considerable size. To investigate this further, I filled the "photoctinometer" with broth instead of distilled water. I used a light calf broth, which in color corresponded quite closely to a 1/400 solution of potassium dichromate; through a 2 cm. layer of this broth a surface culture was illuminated for 2 to 24 minutes, without any noticeable effect of the light; the experiment was repeated after 1 part of the broth had been diluted with 24 parts of distilled water; again a completely negative result after 24 minutes of illumination. Only when the broth was diluted with 48 parts of water, and the thickness of the layer was reduced to 1 cm., was it possible to obtain the relative killing limit after an illumination time of 60 minutes. The layer of diluted broth used would correspond approximately to a 1/2 thick layer of undiluted broth. The light used in the experiment therefore took 1 hour to exert the same bactericidal effect through this layer as it takes 3-41/2 minutes when it has 2 cm. of distilled water to pass through. We have here direct proof of the necessity of eliminating the light absorption of the nutrient substrates when one wants to investigate the effect of light on bacteria. etc.

Finally, I thank Dr. JANSEN for his valuable and tireless help in working out the details of the method.

TREATMENT OF SMALL POTASSIUM WITH THE EXCLUSION OF THE CHEMICAL RAYS OF DAYLIGHT.

OF

NIELS R. FINSEN.

Two colleagues, Mr. District Physician KREBS in Vordingborg and Mr. City Physician LUNDDAHL in Aarhus, have been so kind, at my request, to give me information about and permission to publish some cases of smallpox that they have treated in red light, for which I hereby offer them my best thanks. Dr. KREBS has 1 case, Dr. LUNDDAHL 9, somewhat mild. These cases would not mean much if they stood alone; but they have significance when they are added to the series of cases that are already available. Smallpox is now in any case such a rare disease in this country that one must be grateful for every new case about the effect of its treatment with the exclusion of the chemical rays of light.

District physician KREBS writes the following:

"On September 4, 1900, I had a smallpox patient under treatment; the smallpox had broken out on the 3rd. It was not until the 6th that Pt. was interned in a Döcker felt tent with red cotton cloth for the windows."

The case was of a serious nature, and the smallpox would certainly have become confluent, not only on the face, but also on its places on the body, if the patient had not been treated.

in red light. (He had 108 cups on his right hand alone, and here there are almost none in comparison with the rest of his body," said Pt.).

Many papules had become vesicles and some pustules, especially on the face when he was exposed to red light. An hour later the itching, stinging, heat and tension of the skin which accompany smallpox began to subside, and the next day the swelling had noticeably diminished. Neither vesicles nor pustules developed further; there was neither suppuration nor suppurative fever.

In place of the ugly brown and gray spots known from earlier times, there remained a number of lively, pinkish-red papules which could be pressed away with the finger, but which, as soon as the pressure ceased, filled with blood again due to abundant vascularization. A number of punctate depressions remained on the face, but no real smallpox scars.

"To me, who has seen cases of smallpox in large numbers several times in the past, the mild course during the treatment in red light must have seemed quite astonishing, and the treatment should probably be carried out consistently in the future, whenever the disease should appear, since in my opinion it must be considered to be of great and far-reaching importance."

Mr. City Physician LUNDDAHL writes to me on 7/11 1901:

"By appointment I hereby send a brief summary of my smallpox cases with special regard to their treatment in red light and their presumed results."

No. 1. 5-year-old girl. Vaccinated with good response during the incubation period. Scattered varicella-like eruption. First observed later in the disease, when scattered infiltrations with tough, resistant crusts had formed, which were slow to fall off and left scars, which were, however, quite superficial. Not treated with red light.

No. 2. 7-year-old boy, not vaccinated. Severe initial symptoms. Ill on April 15, 1901. Papular exanthem appeared on April 16-17. Admitted to hospital on the 17th. 3-layer red shirting over the windows. The room became very dark. The hallway was opened to daylight for a very short time. The exanthem spread and became vesicular. At the same time the temperature fell, but the severe deterioration of the general condition persisted. On the 22nd-23rd the suppuration began, the temperature rose slightly in the morning (c. 38); in the evening it had been 38 to 38.5. Confluence of the exanthem, continuous crusts over large areas with underlying "fluttering" pus. Decomposition with a disgusting stench. Around the 24th. Age approaching 40. Died on the 26th of April.

This case had manifested itself from its very beginning as a particularly violent one. Although he was placed in the "red room" early in the illness, even with very little light, the case nevertheless proceeded apparently unaffected by this. The only effect could perhaps be that a high fever did not occur at the beginning of the suppuration stage. It only came when the pus began to decompose.

No. 3. 4-year-old girl, sister of the previous one, vaccinated immediately at the outbreak of the disease, no attack. Exanthema began weakly on the 18th, clearly advanced on the 19th of April. Admitted on the 19th in the morning in the same room as the brother. The general condition was very poor, although without high fever, the first few days. The exanthema spread everywhere, but did not become confluent; on the 23rd-24th the contents of the vesicles began to turn yellow, with a slight increase in temperature (morning 38.4), but the next day the general condition improved quite suddenly. On the 25th-26th the pustules began to dry into looser, less cohesive crusts, which fell off quite quickly, leaving large, red, round spots, especially on the uninjured

covered skin areas, which lasted a long time; some scars also formed on the face, although rather small and superficial. On May 4th, red light was discontinued. She was given baths from the beginning of the encrustation period. The exanthema itched only very slightly.

No. 4. The mother of the children had so slight an exanthem that it was worth treating her in a red light. The attack was so slight and not even considered to be a nuisance.

No. 5. Her infant child, 3 weeks old, was attacked together with the mother (vaccinated shortly before the outbreak, no attack. At first only very sparsely scattered exanthema, a few vesicles here and there and apparently well-being. Only about 8 days into the illness did vesicles appear to a greater extent, become confluent, and finally almost the entire surface of the body was a suppurating surface. The child died on the 28th. When the exanthema broke out more strongly, red curtains had been hung around the cradle, but in the first days, when the eruption was so very slight, nothing had happened in that direction, which must have turned out to be a mistake.

No. 6. A washerwoman in her fifties. Infected from the aforementioned family. Ill on 25/4. On the morning of 26/4, widespread papular measles-like exanthem, Tp. c. 41, general condition greatly affected. Admitted the same day, morning-afternoon, placed first in a room with red window curtains, later in a room with red panes. That evening, Tp. 38.8, became normal in the next couple of days. On the widespread initial exanthem, quite a few scattered vesicles formed, but the majority of the exanthem disappeared without a trace. The general condition improved very quickly. The vesicles quickly dried up into small, tough crusts, leaving some minor infiltrations and, on the palm of the hand, a few small blood oozes under the epidermis. Overall, the exanthem had a quite abortive course. She remained in the red room for approx.

12 days. Through the red windows, which were used in the future, considerably more light came into the room, the patients could see, read and work and were generally comfortable in this light, there was never any particularly strong desire to get out of there. I cannot say whether the greater amount of light that came in, and this was also in the very bright spring months, played a part in the fact that — none of the patients, not even the most easily affected, completely avoided scars, which were not very deep and would probably be almost completely erased in the future. (The scars only appeared on the uncovered parts of the skin). But even if that were the case, most patients would perhaps prefer such a brighter "red room" to a dark one, even with the risk of getting some small scars on their faces. I do not believe that the patients would have sneaked out to let in daylight. In addition, they — were too interested in the Treatment and afraid of violating it.

No. 7. 5-year-old girl, vaccinated with good response during the incubation period. Ill on 2/5, vesiculos eruption on 3/4, on 4/5 very widespread vesiculous exanthem with yellow pus-like content. General condition very little affected, Tp. from hospital admission on 4/5 not over 38. Desiccation quickly set in in the form of light, loose crusts and scales. Almost no itching. Laid in red light from 4/5 - 18/5. On discharge in mid-June large, red spots all over the body. Small scars scattered on the face.

No. 8. 65-year-old woman, not vaccinated since childhood. Ill on 4/5. The next day widespread vesicular eruption, which increased in the following days, became confluent on the inside of the thighs and was very tight all over. Also strong mucosal eruption. Tp., which was 39.6 on admission, fell rapidly, was already 38 the next evening on 5/5, remained low the next days, but went up to 38 on the 8th in the evening and on the 9th in the morning, when in the severe and widespread eruption

The contents of the vesicles became purulent. Desiccation began early, on the face in the form of tough, dark crusts, on other parts of the body as scales and small yellowish crusts, mainly just peeling. The mucous membrane eruption subsided very abruptly. The general condition after the first couple of days was good. I — lay in red light for a good 14 days. Slight scarring on the face as in the previous cases.

No. 9. A child died of purpura variolosa within an hour of admission to the hospital.

No. 10 and 11. Young women, not vaccinated since childhood, with mild variolae discretae on the transition to varioloids. Each of them was observed for about 4 days at home. Treated with red light from admission for about 10-12 days, the vesicles dried up into small crusts or disappeared completely, leaving small red spots. However, a few of them on the face left scars similar to those previously described.

No. 12. Young woman (in her 30s), ill on May 15, papular eruption on May 17, vesicular eruption beginning on May 18. High fever and severe initial symptoms; the exanthema became widespread. Severe mucosal eruption. Admitted to — hospital on the morning of the 1st. Her general condition, somewhat affected in the first few days (she was also in the 5th month of pregnancy), improved considerably from May 21. At this time some of the vesicles began to have yellow contents (no particular increase in Tp. corresponding to this stage). The course of the eruption was generally as follows: In the forehead the vesicles dried into small crusts, in the rest of the face the contents were resorbed and papular infiltrations remained. On the body and especially on the lower extremities, the vesicles were filled with yellow contents, which, however, were also resorbed, in some places small yellowish loose crusts formed, in most places only scales. The mucous membrane eruption subsided quite abruptly. She was in red for a good 14 days.

Room. On discharge from the hospital on June 28, the face was densely covered with red spots, and especially on the forehead numerous scars formed, closer together but not deeper or, in each case, more widespread than in the previous patients.

Nos. 13, 14, 15, two young women and a small child, all from the country, came in so late and with such mild cases that there was no question of red-light treatment in their case.

With regard to the effect of the red-light treatment, one can perhaps say that it had no particular significance for No. 2, and that No. 3 progressed well may be attributed to the treatment. Whether No. 5 had been saved by treatment carried out from the beginning is perhaps doubtful in view of his young age. No. 6, who began violently and progressed abortively, and No. 8, who despite a rather violent beginning and extremely widespread exanthem, nevertheless took a quite benign course, as well as No. 12, who also showed a very widespread eruption, and in whom the condition was quite precarious in the first few days, may also be counted among the good results of the treatment. Whether it has had any significant significance for the initially mild cases of Nos. 5, 10 and 11 is probably uncertain."

When I had received these medical histories and it seemed to me that the results, both with regard to the entire course and with regard to the scarring, were less good than they usually are with treatment in red light, and since it is mentioned in Journal No. 2 that daylight was let in at the entrance for a very short period of time, it occurred to me that the less favorable results were perhaps due to such short-term access to daylight. I therefore wrote to Mr. Stadsläge Lund-dahl and asked for information on this question, which, of course,

is of great interest, since we do not really know for sure how much light or how long exposure to daylight is sufficient to cause damage. Furthermore, I asked how the patients' skin was now, after half a year; experience shows that even if patients have small scars when they are discharged after red-light treatment, these disappear after a certain time, since they are so superficial.

Mr. City Physician Lunddahl showed me the kindness to immediately examine the patients again, which revealed that "only Patient No. 3 could be described as to some extent co-parous".

With regard to Daylight, I received the following information:

"Daylight was let in during the hallway for all patients. For the first two, the curtains were lifted a little to the side. For the others, the windows were opened a crack. There was never any question of longer exposure to daylight; in half a minute you can see a lot, and I don't think it was longer in the hallway. On the other hand, it may have been a couple or more times a day from time to time. Under the circumstances, there could be no specific hallway time, so the patients could not be demonstrated at specific times, but the colleagues here could go in when they wanted to and see the patients. This meant that they were exposed to daylight more often, but for a shorter time at a time."

This information is of great interest and gives these case histories an increased significance, as we seem to have here a clear confirmation that even very short exposures to daylight have a harmful effect and should be avoided. On the other hand, the use of candles or an ordinary kerosene lamp in the hallway will not cause any inconvenience to the patients. It is even very possible that one

Candles or kerosene lamps could be kept burning in the sickrooms all day long, without harm to the patients, because there are so few chemical rays in such light. But the opportunity to experiment with this is rare. A series of experiments by which one could investigate and determine what artificial light and how strong artificial light smallpox patients could tolerate without suppuration would be of great practical importance, partly because some people seem to have an aversion to red light, and partly because the treatment could then be carried out everywhere, even where there were no red panes or red carpets to hang over the windows.

I would like to point out here that now, after the method has stood the test everywhere, it should be considered the doctor's first duty as soon as he has made the diagnosis of smallpox to see to it that the windows of the hospital room are in some way tightly covered and that a light is turned on. When the treatment can be so easily arranged, it is not really advisable to leave the patients exposed to daylight until they can get into the red light of the hospital; time is precious, and the sooner the treatment is begun, the more chance there is for the patients to avoid suppuration and its consequences.

TREATMENT OF THE ROSE WITH THE EXCLUSION OF THE CHEMICAL RAYS OF DAYLIGHT. BY NIELS R. FINSEN.

When I published my treatment of smallpox with the exclusion of the chemical rays of daylight eight years ago, I emphasized that this was not a special treatment for smallpox, but a new therapeutic principle which could reasonably be of importance in other exanthematic diseases and skin diseases; I drew attention to how interesting it would be to find out whether the chemical rays had any influence on these diseases or not, and emphasized how easy it would be and also quite harmless to make such experiments, e.g. with measles, scarlet fever and rubella. I made some efforts at that time to get such experiments started, but as I encountered some difficulties and was also ill and not very capable of work myself, it came to nothing, and I therefore limited myself partly to some statistical studies to see if there was a difference in the course of the diseases mentioned in summer and in winter, and partly to suggest how to carry out trials and control experiments.

Some time later I received from Mr. Corps Physician Dr. med. KIER, who was then Chief Physician at the Garrison Hospital, a gracious offer that I might be allowed to make experiments.

with this treatment in his department. As there were just a few cases of rose, we started with this disease. At my request, Dr. KIER took over the entire treatment, I was only helpful with the installation. In total, only 7 cases of rose were treated, as Corps Doctor KIER's term of service expired just in those days, and the new chief physician did not appreciate continuing the experiments. As I thought the cases were too few and too poorly defined to allow any conclusion to be drawn from them, either positive or negative, they were not published.

Now, however, a report has recently appeared from Dr. KRUCKENBERG, chief physician at the municipal hospital in Liegnitz, about a number of cases of the rose, treated in red light. This has given our 7 cases some value as a supplement to Dr. KRUCKENBERG'S. I have now obtained permission from Dr. KIER and the present chief of the garrison hospital, staff physician BJERRING, to publish them and hereby offer them both my best thanks.

To avoid misunderstanding, I would add that it is not my intention in this publication to attempt to take the priority from Dr. KRUCKENBERG; but since these 7 case histories did not give such favorable results as Dr. KRUCKENBERG has obtained, it seems to me that there is special reason for, and that I have a certain obligation to, publish them now.

I will first present a review of Dr. KRUCKENBERG'S thesis, which is due to Dr. JANSEN, and then Dr. KIER'S medical histories.

HERMANN KRUCKENBERG: Traitement de l'erysipèle dans la "chambre rouge".

Revue internationale de thérapie physique. 1 February 1902.

The author, who is the head of the municipal hospital in Liegnitz, has treated a number of cases of erysipelas in red during 1900.

Room, prompted by an article by Dr. Bie in "Therapeut. Monatsh.", where a comprehensive presentation of the entire Finsens phototherapy is given, both the "negative" and the "positive".

Right at the beginning of the article, Dr. K. says that he has come to the conclusion that this treatment has a very favorable influence on the disease, and adds in a footnote that Dr. Roemer at the same hospital has also successfully adopted the method. But on the other hand, he himself emphasizes how difficult it is to say anything certain after a single, rather short series of admissions; especially when it comes to a disease like erysipelas, which can be very capricious in its course and can sometimes be cured spontaneously in a couple of days, which has given rise to the superstition that Rosen was cured by magic spells.

Dr. K. has had occasion to use the treatment on 13 persons. By counting the relapses as independent, he gets a total of 18 cases. The 15 were of the usual type of facial erysipelas, the 3 had their seat partly on the body and partly on the lower extremities. All the patients came into the red room shortly after the onset of the disease, and with the exception of the first 3, who got some alcoholic compresses, no other treatment was applied either internally or externally. Dr. K. does not seem to have treated other erysipelas patients in the usual way during the same period. However, it would have been a somewhat safer starting point for the assessment of the new treatment than Dr. K. to refer to the fact that the average duration of the facial erysipelas is set at at least 1 week; for the erysipelas in Liegnitz could have been particularly benign at the time the experiments were made.

The observations that Dr. K. has made during the treatment of these 18 cases in the red room are now the following:

The fever usually lasted only 2 days. Most often it stopped the day after or at the latest the 2nd day after the patient was placed in the red room. Only in 2 cases was it different, but in one it was due to pneumonia, in the other to what seemed to be a completely inadequate exclusion of the harmful rays.

This had been done with a care that cannot be overstated. A sickroom in the epidemic ward had been completely transformed into an excellent photographic darkroom: window panes of ruby glass, walls and floor painted red, lamps like those photographers use with red glass and hoods; even the surrounding rooms: the corridor, the anteroom, the toilet and the bathroom had red windows. In this "really red room" the 14 cases were treated. Of the remaining 4, 3 were in absolute darkness and also gave good results, while 1, and that was the one referred to above, was in quite unfavorable conditions, namely in an ordinary room with 4 windows, which were indeed covered, but which, according to what Dr. K. later heard, had probably been opened during the morning cleaning. In this particular case the fever persisted for 6 days with a temperature of around 39 and 40, the disease propagated, and the general condition was bad.

In discussing the device, Dr. K. touches on how often one finds a complete misunderstanding of the whole matter. There are those who believe that it is a question of treatment with red light, that one should simply let some red rays of light fall on the patient's sick places, just as one can give a steam shower. Dr. K. thus found a place where he had recommended a red room, the following: Pt. lay in his bed in a sea of sunlight, while next to him stood a lighted lamp with red glass! And that was at a doctor's.

But with regard to the exanthema, Dr. K. says that the initially sharp boundaries disappeared within 12 hours, and the progression was gradual. However, a slight redness and swelling often persisted for several days. There was no bulla formation and squamous peeling of the epidermis, as is often the case. The process usually ended with a fine scale.

There were a total of 5 relapses, but none of the relapses occurred while Pt. was in the red room. It was only after Pt. had come out into the ordinary daylight that they occurred. Twice even the same evening that Pt. came out.

Of the complications, only pneumonia was noted in 1 pt. and severe headache and fatigue in the pt. who was inadequately treated.

One would wish that the author had stated how Ptt. was in the red room. However, the matter is still so — new that any information in this regard is valuable.

At the end of his article, the author seeks to substantiate the treatment with a theoretical explanation. Could it be that Streptococcus erysipelas thrives better in light than in darkness? No, this contradicts the numerous experiences about the bactericidal effect of light and some experiments that the author himself conducted. (Here at the Light Institute we have also done some experiments with streptococci. They did not show any particular tenacity towards light). Rather, as Finsen has already said a long time ago, it must be assumed that it is the skin-irritating ability of light that is the cause here. And just as Finsen has stated about smallpox, Dr. K. also believes that a large part of the medicines used so far for rose (such as ichthyol, iodine tincture, etc.) probably only work by keeping the light out. The author also draws attention to some experiments about the — pathology of Negroes, which are very interesting. According to DAEUBLER and PLEHN, Erysipelas and Phlegmone are very rare among the Negroes, and that this is something peculiar to the Negroes and is not due to special climatic conditions seems to emerge from a report from the Hospital in Dar-es-Salaam (in German East Africa), where both Europeans and Negroes are found. Erysipelas is never seen in the latter, quite often in the former. It is possible that it is the pigment of the Negroes that protects them against the disease in question.

The brief case histories that accompany the thesis are reproduced here in extenso.

1. F. W. 24-year-old nurse. The previous year, twice, the facial rosacea lasted 6 and 5 days respectively. Got

1/400. The rose on the nose, half of the left cheek and part of the forehead. Evening temp. 39.6 .

Red Room.

2/4 Morning: 38.5. No Propagation. Evening: fever-free. Redness fading.

2. A. S. 15 years old. Some in pain for 4 days and had been hospitalized. swelling in the face. Had been

21/4. Erysipelas. over almost the entire face. 38.3.

Epithem, alcohol. Red Room.

22/4 $\frac{37.9^{*)}}{38.3}$ Erys. has reached the hairy part.

23/4 36.8 Well-committed 36.6

3. B. J. 19 years old. Has had redness, swelling and bruising of the right leg for 3 days without any apparent cause. Admitted

31/4. Characteristic Erys. of the right leg with irregular borders; peripherally reaching almost to the foot, centrally to the knee. 38.0.

Ep. alcohol.

1/5 $\frac{37.6}{39.3}$ Erysipelas has spread to the foot.

Red Room.

2/5 38 38.5 No Propagation.

3/5 37.8 37.5 4/5 Temp. below 37. The tumor is losing weight.

4. K. P. 25 years old. Admitted 20/4 for sycosis.

2/5 400. An erysipelas develops on the left cheek.

Red Room.

3/5-6/5. Morning temp. approx. 39, Evening temp. approx. 40. Erys. extends over the entire face. Delete General condition.

7/5-8/5 The fever goes down a little.

9/5 Fever rises. Right-sided pneumonia, bloody sputum etc. The swelling on the face is decreasing.

12/5 Fever-free. Well except for some stitches in the side.

5. A. M. 54 years old. Insane. Unwell for 3 days: Fever, swollen nose. Hospitalized

18/5 390. Erys. of the nose and v. K. to the ear.

Red Room.

19/5 $\frac{37.4}{38.6}$. 20/5-21/5 below 37°. The swelling is decreasing.

*) Temp. above the line morning, below the line evening temp. for the day in question.

22/5 Morning: Sunlight. Evening: 39°. Relapse.

Red Room.

23/5 $\frac{37.1}{36.7}$

25/5 Daylight.

6. P. S. 55 years old. For several months treated for glandular tuberculosis on the right side of the neck and in the axilla. 12/6 Evening temperature 38.5. Unwell.

13/6. An erysipelas appears, arising from a fistula and extending over the entire right side of the neck and part of the cheek. Evening temperature 396.

Red Room.

14/6 $\frac{38.8}{39}$ Erys. extends across the right side of the face.

15/6. Cessation of the Fever. Daylight. Still feeling bad. The tumor Does not stop completely until 17/6.

7. O. W. 15 years old. Supposedly had erysipelas a year ago with 8 days of fever. Has had erysipelas over almost the entire left side of his face for 2 days when he was admitted.

15/10. 38.6.

Red Room.

16 10 $\frac{38.0\ 37}{38.2}$ Erys. Øret. 17/10 37.9 to

The following days below 37. The tumor is losing weight. 20/10 Sunlight.

Hand-26/10 Fever towards evening: Recurrence on left cheek.

39.1. Large area of redness.

Red Room.

27/10-28/10. Intermittent Fever.

9/10. Cessation of the fever. But a slight swelling remains over the entire face for a few days.

8. M. T. 25 years old. Has had redness and swelling emanating from the nose and swelling of the face for 8 days. Admitted

5/11. Erysipelas of the entire right side of the face.

Red Room.

/11 37.7 370 The tumor is decreasing. 7/11 The fever has stopped.

9. P. W. 31 years old. Laid in the Eye Department for corneal ulcer. On the night between 29/11 and 30/11, facial swelling.

1/19. Hospitalized for the rose, which occupies almost the entire face. 39.90.

Red Room.

2/19. Evening temp. 39.3. Erys. to the ear.

3/18 $\frac{39}{37.9}$ Minor Headache. Redness fades. 4/12 Fever-free. Minor Tumor. 8/12 Sunlight.

10. O. W. 15 years (No. 7). 26/11 Paany Erysipelas. Admitted 27/11, Erys. already extends over nose, cheeks, lips, eyes and part of forehead. 390.

Red Room.

20/11 $\frac{37}{38.9}$ No Propagation. 29/11 fever-free. The swelling everywhere much reduced. 1/19 Sunlight. Until 6/19 still a slight swelling of the left cheek

11. Th. K., 52 years old. Nurse in the Deaf-Mute Asylum. Got the facial rosacea on 6/10. Characteristic redness and swelling of the nose and Cheek. $\frac{39}{40}$

7/10. Red Room by excluding sunlight as best it could in a room with 4 windows.

Slow Propagation. Temp. unchanged high.

8/10-10/10 Same condition. Clear General condition. Erys. extends into the hairy part.

11/10 Temp. drops. 12/10 fever-free.

12. A. M., 37 years old. In the idiot asylum. 30/10 Erysipelatous redness and swelling on the right side of the face, arising from a nasal excoriation. 37.5°.

Dark room; the staff uses a red lamp when they enter there.

31/10 Below 37°. The redness is fading.

2/11. Still no fever. Redness gone. Right side of face starting to go bald.

13. J.W., 19 years. At the Institute for Idiots. In October. treated for Ozoena.

14/11. Erys. of nose, cheeks and left half of upper lip. 37.80. Dark room (as No. 12).

The temperature stays below 37. The redness does not spread any further and disappears over the next 3 days.

3/18. Fresh erysipelas on the left side of the face and over the left eyelid. Dark room.

4/12 fever-free; but Erys. has spread over a larger part of the body.

6/12. Still no fever. The redness has disappeared.

8/12. Sunlight.

14. H. M., 51 years old. Operated on 19/4 1900 for a recurrence of cancer of the penis. Above the pubis there is another fistula which secretes a little.

2/2 1901. Redness and swelling of the right cheek and lower eyelid suggest erysipelas. 3/9. No fever, but the swelling has spread over the cheek.

Red Room.

Here complete freedom from fever. The swelling immediately subsides and has completely disappeared on 6/9. The patient is sent back to his ward on 8/9. The same evening: 38.5°. A plate-sized erysipelas. originating from the fistula and already out on the left thigh.

Red Room.

Immediate cessation of fever, erysipelas. disappears and its borders contract.

Excerpt from the records of the cases of rose treated in the garrison hospital by the corps physician, Dr. Kier, in a red light:

No. 1. STEENBERG'S WIFE. In hospital from 18/11-28/11 1893 for Erysipelas faciei and Nephritis acuta. Illness. began. 2 days before admission. with chills, severe headache and swelling of the nose. On admission 18/11 Temp. 40.9. Erysipelas on the entire left cheek and eyelid, nose and part of the right cheek. Several bullae.

D. f.
Epith. boric.
Acetanilide
Centigr. 25.

$^{19}/_{11}$ $\frac{40.3}{40.2}$. Erys. now as widespread on the right as on the left. No appetite. Poor sleep due to headache.

Wine, Milk, Ice cream (outside).
Syrup. chloreti morfici. 1 Theskef.

20/11 4. $\frac{39.4}{40.4}$ Erysipelas has spread further up into the hairy part of the body. Part and above the ear. Pulse 108, small.

Red Room.

$^{21}/_{11}$ $\frac{40.4}{40}$. Good Sleep Without Narcotics. Finding something better. The swelling and redness of the cheeks have diminished somewhat, but the affection has spread over the forehead and into the hairline. Pulse 120, quite strong. App. extremely poor, drinks only wine and milk.

$^{22}/_{11}$ $\frac{39.2}{37.6}$. Pulse 93, strong, has been feeling less well yesterday, but is feeling well this morning. The rosacea has not spread since yesterday, and the swelling and redness in the face have diminished considerably, so that the face today is almost completely natural.

Sept. Ice creams.

She is starting to feel like eating.

Sep. D. f.
Rs. M.k.

$^{23}/_{11}$ $\frac{37.5}{37}$. Pt. is doing well overall. She has been sleeping good at night. No headache. No sm. The rose has not spread

sig. The redness and infiltration have subsided well everywhere, also in the hairy part. There are remains of bullae formation all over the face. App. good.

24/11 37 / 36.8 Still subjectively well. Another little tenderness

f. Pressure in the left temporal region. Sep.

Red Room.

In the following days, albuminuria was found, which is why the patient was transferred to another service. There was no recurrence.

No. 2. ANDERSEN*), 23 years old. Admitted 28/11 for erysipelas in connection with a vulnus contus. capitis. Temp. 40.5. Clear erysipelatous redness and swelling of the left cheek and across the left side of the forehead and over the hairy part of the head on the left side.

Rp. D. f. and red Room.

29/11 40.4 / 40.7 Only slept a little last night. I'm pretty exhausted.

P. 108, regular and strong. The rosacea has spread over the entire forehead and down the right cheek. Urine normal.

Rp. 1 Siphon.

30/11 40.5. / 38.7 Subjective Well-Being. Slept well last night without Narcotica. Drinks his milk and wants more. No headache, does not feel particularly tired. The rosacea has spread over the whole face. There is edema of the eyelids. Abundant bullae on the nose. Pulse strong.

Rp. 4 Milk. Sep. 1 Siphon.

1/12 39.6 / 37.5 The rose has spread behind the right ear and around the nape of the neck. region. There is quite considerable redness and swelling throughout the face, especially on the right side. Subjectively indicates well-being. Pulse 60. Urine normal. A large bulla on the nose is completely dried up.

2/12 39, / 39.5 Subjectively indicates Well-being. The rose has spread

*) Where nothing else is stated, Ptt. is Men (Private).

into the left parotid region and to the left ear. On the right side the process has subsided well. Urine normal.

3/12 40.8 / 38.9 He's feeling pretty good, he's slept well after

Syrup. chloral morphine.

1 Teacup.

The rose is strongly pronounced on the left side of the head, especially the left ear. Want to eat more. Rs.

Mk.

4/12 38.5 / 36.5 Well done. Good night's sleep after

Morphine juice, 1 teaspoon.

The erythema has disappeared everywhere except in the left ear, where there is still some tenderness and swelling. Urine normal.

5/12 37, / 36.5. Still insignificant tenderness and swelling of the left ear. Appetite and sleep good. Urine normal.

6/12 36.9 / 36.5 Another small lump in the left ear.

7/12 36.7 / 36.5 Swelling and redness now completely gone. feeling good. App. good. Peeling on cheeks and ears.

Sept. Mk.

Rs. Fk.

8/19. Peeling all over the face and head.

Sept. Red Room.

The following days natural conditions. Discharged 12/12-

No. 3. KNUDSEN, 20 years old. Admitted 19/12. The illness began about 2 days previously. 37.5. The nose is somewhat red, swollen and sore; the same applies to the nearest part of the cheeks.

Rs. D. f.

Red Room.

20/12 37.1 / 37. Well done. The rose has not spread. Urine normal.

Sep. D. f.

Rs. Mk.

21/12 $\frac{37.1}{\text{and}}$ Complete well-being. Swelling and redness of 36.6 nose adjacent part of cheeks have completely disappeared. Peeling of these parts.

22/12 $\frac{37}{36.6}$ Well done. The nose is natural.

Rs. Fk.
e. l.

23/12. Well done. Nose natural.

To be printed.

No. 4. KIRKEGAARD'S WIFE, 32 years old. Admitted 14/12. 2 days before admission. Chills and fever, and redness of the nose. Tp. 41. Nose and cheeks Seat of considerable erysipelatous redness and swelling. Aff. extends to the ears on both sides and up to the eyes. There is no edema of the palpebral. Clear violent borders. Bullous formation on the right side of the nose and right cheek.

Rp. Ice. D. f. Milk.
Red Room.

15/12 $\frac{39}{40\,1}$. Pt. has slept a bit last night after Narcoticum. single vomiting. The redness and swelling have spread to the forehead. Considerable edema of all 4 eyelids. Extensive bullae formation around the nose and on the chin. Pulse quite strong, regular. Urine contained traces of albumin.

16/12 $\frac{40}{39.9}$. Little, interrupted sleep at night. Condition essentially unchanged. The erysipelas has spread somewhat up the hairy part of the head; but swelling and redness of the face as well as the edema of the eyelids have considerably diminished. Some egg white in the urine.

17/12 $\frac{39.5}{39}$. I slept fairly well last night after taking morphine. The rosacea has spread to the neck and over the ears. On the other hand, it has diminished considerably on the face and all the bullae have dried up. I feel better overall. I am eager to eat.

Rs. Mk.

18/12 $\frac{38.4}{37.}$. Slept well last night without narcotics. Good condition today The erysipelas has not spread. Still swelling and redness of both ears and the nearest adjacent part of the neck. No particular tenderness in the hairy part of the head. Face very flaky. Good appetite. There are traces of egg white in the urine.

Sep. Ice Cream, Milk and Wine.

19/12 $\frac{19\ 36.9}{37}$. Good night's sleep. All the best. Rosen almost gone everywhere, only a little soreness in the neck.

12/20 $\frac{37}{36.8}$ The rose now faded everywhere.

Sep.
Red Room.

The albuminuria persisted until discharge on 23/12.

No. 5. STEENBERG. Admitted 18/12. Illness began 11/2 days ago with strong chills. Currently very ill, drowsy and pale. Temp. 40. Considerable erysipelatous redness of nose and adjacent parts of cheeks.

Rs. D. f.
Red Room.

19/12 $\frac{40.3}{40.3}$. The redness and swelling have spread greatly. over the cheeks and up to the forehead. There is edema of all eyelids. Bullae formation on the cheeks. Has slept last night without sleeping pills and still dozes a lot. Pulse regular, but a little slow.

20/12 $\frac{8\ 39.8}{40}$. Sleep has been bad last night. The rose has spread extends over the forehead and all the way to the ears. On the other hand, it has faded a little on the cheeks. The general condition is generally bad.

21/18 $\frac{40.9}{40.1}$. Pulse 108, regular, strong. He states that he feeling better. Slept a little last night after taking morphine. The rosacea has spread up the hairy part of the head to a line corresponding to the coronal suture. Quite a lot of swelling and tenderness of the forehead. The affection has disappeared on the cheeks and nose. Bullae are

parched. Peeling on the face. Quite thirsty. No appetite.
Urine normal.

22/12 40.4/39.7. Pulse 96, regular. Slept well last night after Morphine-

juice. Feeling better overall. The rosacea has spread to the Isse and Tindinge regions, but has diminished considerably on the face.

23/12 40.1/39. Bef. seems to be a little better. Today Tumor and

Soreness of the entire neck region and right ear. In the face, Rosen has lost a lot of weight.

24/12 40.4/38.5. Was cloudy during the day yesterday. Wild out-

written and out of bed. Slept peacefully last night without morphine.
Bef. himself in the morning quite food. The rose is almost unchanged. Beginning
well. to get an appetite for

Rs. Mk.

25/12 40/37.5. Feeling better. Wasn't foggy yesterday.

Slept well last night. The erysipelas has hardly spread, but there is a little swelling and tenderness on the left side of the neck and right ear. The process on the face has subsided well, there is very severe peeling.

26/12 40.3/40. Today the rose has appeared again in the left half of the face.

Edema of the left eye's palpebral fissure. Some drowsiness. Pulse 86, regular, quite strong.

27/12 39.8/37.5 Have slept last night. The rose has not spread, but

it begins again on the left half of the nose.

28/12 39,1/37.5 Is doing quite well. The rose is now back in Africa.

tagende.

29/12 39,6/37.6. Get well soon. Still redness, swelling and tenderness

of left ear. Very severe peeling on face.

30/12 37.2/36.6. Well done. Good night. Still only the rose of

v. Ear. Urine normal.

31/12 40.6/37.8. Felt unwell last night. Chills. Sm. behind

v. Ear. Today Bef. is better, and Sm. has lost weight. Nothing objectively abnormal. The erysipelatous process has stopped everywhere. Strong
Peeling. Sep.

Red Room.

The following days are OK. Discharged 4/1.

No. 6. HANSEN, 22 years old. Admitted 24/19. Illness. started about.
2 days ago. 37.6 and nearest part. redness of nose No bullae. No clear
of left cheek. There is erysipelatous border
for the Process. Rs. D. f.

Red Room.

25/12 38.5/39. The rose has spread to the left ear. There is now

clear violent boundary upwards at the Tindinge region.

26/12 40/39.9 The subjective feeling is good. I have slept.

good. Appetite good. The rosacea has spread over the right half of the face and over the hairline. Urine normal.

Rs. Mk.

27/12 39.5/37.6. The rose has spread a little towards the left ear. Well done.

28/12 38.3/37. The rose today is strongly pronounced in the left ear.

29/12 37.7/37.5 Still redness and swelling of left ear. Severe tenderness.

and swelling of the glands behind the left ear. Subjectively well.

Rp.
Epithem. tepid.

30/12 37.5/37. The aforementioned tenderness of Old has lost its weight. Yet

Redness and swelling of the left ear.

Rs. Fk.

31/12 $\frac{36.7}{36.6}$. Completely fine. Still only a little redness.

of left earlobe. Sep.

Red Room.

The following days still well. Discharged 6/1.

No. 7. KIRKEGAARD'S WIFE, 32 years old (refers to No. 4). Admitted 26/12. Became ill again immediately after discharge from previous hospital stay. 39.9. There is some redness and swelling of the nose and the nearest part of the cheeks. Some edema of the lower eyelids of both eyes. On the nose a few bullae.

Rp. D. f. Milk and Wine.

Red Room.

12/27 $\frac{39.7}{37.9}$

37.6 —. 28/18 37 Pretty good sleep at night. Overall better.

The rose has not spread. The urine is normal.

29/12 $\frac{37.6}{36.9}$ Well-being No Spread of the Rose. Face

almost natural.

30/12 $\frac{37.6}{37}$. Well-bef. Rosen has lost some weight in her face,

Still some tenderness and swelling in front and behind the ears. Urine normal.

Sep. Milk and Wine.

Rs. Mk

31/12 $\frac{37}{37}$ Well done.

Printed 9/1.

As can be seen, it is not possible to draw any reasonable conclusions from these last 7 case histories. In the few cases (Nos. 1, 2 and 3) where a favorable effect of the treatment could be assumed, it is possible that the course would have been just as favorable without treatment. On the other hand, the cases where the fever persisted and the disease

spread despite the treatment, nor is there any conclusive evidence that the treatment is ineffective, for without this treatment the course would possibly have been even worse. The capriciousness of this disease makes it impossible to draw conclusions from it. All we can say is that Dr. Kruckenberg's case histories undoubtedly give an overly favorable picture of the effectiveness of this treatment in the rose.

However, there is every reason to continue with these experiments, which should preferably be carried out in a larger hospital and quite systematically with trials and control trials. This treatment has in any case the advantage over so many others that it is harmless, so that one need not have the slightest misgivings about conducting experiments with it.

LITERATURE REVIEW.

PAUL DARBOIS: TRAITEMENT DU LUPUS VULGAIRE SUIVANT LES INDICATIONS. Paris 1900.

The author reviews the technique and results of a number of different methods of treatment for Lupus vulgaris, about 30 in total. Of these, he believes that the following are capable of curing the disease: Scarification, Ignipuncture, galvanocaustic Scarification (scarification ignée), the surgical methods (excision, scraping), Caustica, Finsen's Method.

Of the newer treatment methods, the author believes that the following are not capable of curing the disease: Koch's Tuberculin TR, Streptococtoxin, various sera, Holländer's Hot Air Method, Calomel Injection, d'Arsonval's Currents (high frequency and high intensity currents), Electrolysis, X-rays.

It is interesting that d'Arsonval's currents, which have given good results against lupus erythematosus, have no improving effect whatsoever on lupus vulgaris.

An ideal treatment, says the author, must be easy to use and painless, and must quickly provide definitive healing and beautiful scars. Regarding these individual points, he notes that, 1) none of the other methods produce scars as beautiful as those obtained by scarification and the FINSENS method. 2) Definitive healing can be achieved by all of the methods mentioned, provided that the patients can be kept under observation for at least 2 years to treat any relapses and remaining lupus foci. The author therefore does not consider it a

Objection to the FINSENS method, that patients must as a rule undergo one or more short-term follow-up treatments in the first couple of years after the completion of the main treatment. 3) The quickest treatment is undoubtedly excision, provided that suppuration is avoided. This method is therefore recommended by the author in cases where the disease is operable and is located in a place where the appearance of the scar is of secondary importance. In second place, as far as speed is concerned, is the FINSENS method. With all other methods, including scarification, it takes longer to achieve healing than with the FINSENS method.

4) The author rightly considers the painfulness of the treatment to be one of the most important points. None of the other methods can stand in this respect alongside FINSENS, which causes no or almost no pain.

From the above it will be seen that the author considers the FINSENS method to be the most perfect. In his "Conclusions" he has expressed this view in the following way: "The FINSENS method is indicated in the majority of cases. However, lupus on the mucous membranes cannot be treated with this method. Furthermore, it cannot be used with people in the country and poor people who cannot get to the hospital."

"With these reservations, it can be said that, due to the relative rapidity of the effect and the excellent scars it produces, the FINSENS method is the best of all the treatments used in lupus therapy."

This recognition of the superiority of FINSENS's method is given increased significance by the author explicitly noting in his introduction that "it is Dr. Brocq who first had the idea for this work, and it is he who has partly inspired the conclusions."

VALDEMAR BIE.

LEREDDE: LA PHOTOTHÉRAPIE ET SES APPLICATIONS A LA THÉRAPEUTIQUE DES AFFECTIONS CUTANÉES. Bulletin général de thérapeutique. 70e année, t. 141 p. 129.

CLAY: LA CURE PHOTOTHÉRAPIQUE DU LUPUS ÉRYTHÉMATEUX.
Bulletin de la société de thérapeutique. 36° année, 4ª série, t. VI, no. 1, p. 21.

The author gives a detailed account of FINSENS's "La Photothérapie", and also publishes his own experiences of treatment with concentrated light according to Finsen's method.

Regarding the results of the treatment of lupus vulgaris, the author is of the same opinion as Darbois: FINSENS' method is the least painful and gives the largest percentage of cured cases, the surest definitive cure, and the most beautiful scars. He also has only one objection: the expensiveness of the treatment will prevent poor patients who cannot come to the hospital from using it. But he assumes that the head of the public charity will understand that it is cheaper to pay for the cure of such patients than to have them sooner or later put in the poorhouse.

LEREDDE has treated a patient with acne rosacea nasi. Considerable improvement was achieved, but so slowly that if it always goes like this, LEREDDE can only recommend light therapy in the few cases of this disease that cannot be cured by the usual methods of treatment.

On the other hand, he has been very satisfied with the results of light therapy in a severe case of Rhinophyma; the lower end of the nose was twice as large as normal and transformed into a blood-filled sponge. After 30 sessions of 1/2-1 hour duration, a significant reduction of the nose was achieved, and the color became pink.

The author has also treated two cases of sycosis several years old which had resisted all treatment. In one case, after 12 sessions of treatment, a very marked improvement was achieved.

In "la Société de thérapeutique" LEREDDE has published his experiences on the treatment of lupus erythematosus with concentrated light according to the FINSENS method. He has treated 11 cases, almost all of which had previously been treated with the greatest perseverance, but without result, with almost all the known methods.

It is of particular interest to Forf that one of the patients, who had previously been treated without results, including 70 sessions with D'ARSONVAL'S currents — In his and BROCQ's opinion, one of the best treatment methods for Lupus erythematosus was — significantly improved by 22 sessions of light therapy.

In 2 of the 11 patients treated, only a slight flattening, reduction of congestion and atrophy of the epidermis at the treated sites have been achieved. The author notes that the treatment has been too short (10-12 sessions) to allow any definitive judgment to be made.

In 3 severe cases, the author has achieved partial recovery and, for the rest of the suffering, considerable improvement.

Finally, in 3 cases complete recovery has been achieved after 35, 7 and 45 sessions respectively, and 3 other patients, whose treatment has not yet been completed, have improved so much after 40, 22 and 30 sessions that LEREDDE dares to predict complete recovery. All in all, LEREDDE believes that FINSENS' method is the best method for treating the severe forms of Lupus erythematosus.

VALDEMAR BIE.

MALCOLM MORRIS AND S. ERNEST DORE: REMARKS ON FINSENS LIGHT TREATMENT OF LUPUS AND RODENT ULCER. British Medical Journal Nr. 2093, 9. Febr. 1901, p. 326.

This article contains, among other things, some valuable remarks regarding the technique of treatment, the skin reaction, favorable and unfavorable conditions for the treatment, etc.

In all the cases of lupus vulgaris that the author has treated, there has been a clear and regular improvement, although in some cases very slowly.

There has also been a clear effect on lupus erythematosus, although not as certain as on lupus vulgaris. A medical history is given which definitely indicates that in the treatment of this disease it is important to produce as severe a skin inflammation as possible.

Most interesting are Forff.'s observations on Ulcus rodens. They believe that the light has a distinct stimulating effect on the tissue at the base and edge of ulcerations, both in lupus vulgaris and in Ulcus rodens, so that soon after the treatment a rapid ingrowth of epithelium from the surroundings begins. In some cases, where the epithelium was not ulcerated, the tumor after the treatment became red, slightly excoriated and softer, and disappeared little by little without loss of substance.

VALDEMAR BIE.

STEPHEN MACKENZIE: ON PHOTOTHERAPY, OR THE LIGHT FREATMENT OF LUPUS VULGARIS. The British Journal of Dermatology Vol. 11, Nr. 133.

LORTET ET GENOUD (FACULTÉ DE MEDICINE DE LYON. LA-BORATOIRE DE PARASITOLOGY): LA LUMIÈRE AGENT DE THERAPEU-TIQUE. Lyon 1900.

THEODER SCHÜLER: UEBER LICHTBEHANDLUNG MIT SPECIALIZES BERÜCKSICHTIGUNG DER PROFESSOR FINSEN'CHEN BEHANDLNUG MIT KONCENTRIRTEN CHEMISCHEN LICHTSTRAHLEN. Monatsschrift für orthopädische Chirurgie und physikalische Heilmethoden. Vol. I, No. 3, 1901.

HENRY W. STELWAGON: PHOTOTHERAPY IN CUTANEOUS MEDICINE. The University Medical Magazine, Dec. 1900.

These four treatises contain accounts of the author's visit to Finsen's Lighting Institute.

VALDEMAR BIE.

MAGNUS MØLLER (Stockholm): Der Einfluss des Lichts auf die Haut in gesundem und kranhhaftem Zustande.

Bibliotheca medica. Abt. D. II, Dermatology und Syphili-dologie, herausg. v. Prof. GENESIS. 142 pages. E. Stuttgart 1900.

NÄGELE.

In this book, which is furnished with beautiful photographs and histological plates, the author gives a comprehensive presentation of recent years' research into the effects of light and X-rays on the skin. The effect of sunlight and electric light on healthy skin is treated with great care, and the significance of light for "summer prurigo", Hydroa æstivalis, Xeroderma pigmentosum and related disorders, as well as the effect of light on pellagra and the FINSEN treatment of smallpox.

The author also reports some lighting experiments he himself has carried out, with accompanying histological investigations of great interest. He has used the same lighting apparatus with which WIDMARK in his time carried out the fundamental experiments on the skin-irritating ability of ultraviolet rays, namely a water-filled metal cylinder, one end of which was closed with a lens of rock crystal with a focal length of 13 cm., the other with a flat glass plate with a cutout in which a flat rock crystal plate was inserted. The rays from an electric arc lamp of 1200-4000 normal lights were made parallel by the rock crystal lens mentioned and then passed the water layer and the glass and rock crystal plate, behind which the author illuminated his own skin or the skin of experimental animals. His experiments led to quite similar results as WIDMARK'S and FINSENS'S. When using a suitable light intensity and a suitable exposure time, only the areas of the skin that corresponded to the rock crystal plate showed erythema, while those of the rays that had passed through glass showed no such effect, from which the author concludes that the effect must be due to the ultraviolet rays, although, as he himself points out, one does not dare to conclude that the visible rays cannot have a similar effect on the skin even at higher light intensities. As an effect of the ultraviolet rays, the author observed, in addition to the well-known vasodilation, a decreased transparency in the epidermis as a result of proliferative processes. This "clouding" of the epidermis appeared 2-3 days after the exposure; it increases in the same proportion as the photochemical redness decreases, and it persists until the peeling stops. It appeared particularly clearly when the treated skin area, e.g. on a rabbit ear, viewed in transmitted light. Histologically, the lesion is due to

reduced transparency "a parenchymatous edema, an abnormally increased sap content in the epithelia with accompanying hyperplasia", which is particularly evident in the case of the stratum corneum, which becomes more than twice as thick as normal and shows an abnormal process of cornification, as the nuclei of the corneum cells are well preserved and are affected in an abnormal way by dyes. This process, caused by the ultra-violet rays, serves, in the author's opinion, to protect the deeper layers in a similar way to the cardilation and the later occurring pigmentation.

The author investigated the deeper effects of light particularly on the ears of white rabbits, by using WIDMARK's apparatus to concentrate the light on the inside of the ear. With a suitable light intensity he not only obtained an inflammation limited to the rock crystal part with bulla formation on the inside of the ear, but also a corresponding, albeit less severe, affection on the outside of the ear. The author regards this as proof of the "not insignificant deep effect of the ultraviolet rays". In view of what we otherwise know about the poor ability of the ultraviolet rays to penetrate deeply, it is perhaps doubtful whether the author is right in this view; it is perhaps more a question of a collateral flux of considerable intensity. The histological examination of the vascular dilations showed, — among other things, a very strong dilation of the smaller arteries; While their lumens generally appear on section to be surrounded by a thick, more or less contracted muscularis with a strongly folded elastica, the light-exposed arteries, on the other hand, showed a thin, distended muscularis and an almost smooth elastica, so that they more resembled veins than arteries. At the strongest illumination used, thrombus formation occurred in the skin vessels.

A series of experiments on guinea pigs and rabbits with the intention of investigating whether "solar stasis" can be induced by exposing the heads of these animals to strong ultraviolet light led to negative results, nervous phenomena only occurring in cases in which the heat rays were not sufficiently carefully excluded.

SOPHUS BANG.

SØREN HANSEN: On the Sunlight in Copenhagen. Some Remarks on the Occasion of the Revision of the Building Act.

Journal of Health Care. 1 R. VII. P. 65-78.

The author would like to draw attention to the fact that the Building Act should take into account the lighting conditions of streets and homes to a much greater extent than has been the case so far. The focus of the Building Act has certainly gradually undergone a very commendable shift, as the regulations, which were dictated solely with fire risk in mind, now increasingly focus on hygienic conditions. But a sufficiently open view of the hygienic significance of light seems to be lacking so far. Copenhagen is already treated rather stepmotherly by nature when it comes to sunshine. Of the 4400 theoretically possible hours of sunshine per year, the sun only shows itself for 1200, while, for example, Berlin has 1727. Of the larger cities, only London (with 1026 hours) seems to lag behind us. Added to this is the poor quality of a large part of the sunshine that we are given. One would think that in these circumstances there was an invitation to erect the buildings in such a way that they take as little sun from each other as possible; but the author's calculations show that our building law, far from being perfect in these respects, on the contrary places us more unlucky in terms of sunlight on the facades than the cities with which we could be most closely compared, e.g. Berlin. In our country, the height of the house is not allowed to reach 5/4, and under certain circumstances even more, of the street width; in Berlin the height of the house may not exceed the street width. This means that in a street running east and west, with houses 27 cubits high, the northern row of houses in Berlin will at noon on the equinox have a vertically 6 cubits larger sunlit area than the corresponding row of houses in Copenhagen. In order to achieve the Berlin lighting conditions, the southern row of houses in Copenhagen would only have to be / of the width of the street instead of the prescribed 5/4. For the inner city, such requirements cannot of course be implemented; on the other hand, it would be possible for the suburban districts, for which the author even suggests the normal ratio of 2/3, which would mean that the southern row of houses at noon on the equinox could not shade any part of the northern row of houses. It is to be hoped that what they now

The ever-increasing demand for brighter light as a comfort and the growing understanding of the hygienic importance of light in combination could cause the author's very appreciable proposal to be taken under closer consideration by the authorities.

SOPHUS BANG.

HUGH WALSHAM: On the ultra-violet light from a rapid oscillation high-tension arc, for the treatment of skin diseases. — The lancet. — Feb. 1902.

Ultraviolet rays with a wavelength of about 200 μμ make the air through which they fall conductive to electricity. The author has used this — property to investigate the penetrating power of these rays. As a light source he uses an alternating current — lamp, which is not described in more detail. When the rays from this lamp are directed towards an electroscope charged with negative electricity, its gold leaves will collapse, and the author uses the speed with which this occurs as a measure of the amount of the rays in question. By inserting various bodies between the lamp and the electroscope, he determines their absorption ratio. According to the experiments, 2-2 mm thick quartz plates at a distance of 10 mm from each other will absorb 60% of the rays that affect the — electroscope. If the space between the plates is filled with water (distilled? boiled?) 10-15% of the remaining rays are retained. A gelatin plate of 0.04 thickness stopped all the rays while a 6 inch thick block of ice hardly absorbed more than the corresponding air column.

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This circumstance led the author to use small, inch-thick pieces of ice as compressors in the case of Lupus's lysophia instead of the Finsen pressure glasses. The author assumes that the cold effect of the ice will also contribute to complete the local ischemia. —

The fact that the author has been able to use this technique at all is explained by the fact that he uses a weak light source without concentration of the rays for the treatment of lupus, and that the sessions do not last longer than 10-15 minutes. Experiments at Finsen's Light Institute have shown the inadequacy of both parts, and in addition, rays —

with such great fragility is absorbed into the very top layer of the skin. — The author admits this, emphasizing that the penetrating power of light rays decreases with their wavelength, but he tries to get around the matter by saying that "the wavelength is so easily lengthened or shortened when the rays strike different bodies that it would not be wise to dogmatize on this point."!

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It goes without saying that such use of ice as a compression agent must also be very troublesome for the patient; the author does not even mention this side of the matter.

GUNNI BUSCK.

G. J. MÜLLER: Actinotherapy. — calendar und Recipe Taschenbuch. 1902. Berlin. Medicinal

Under the name "Aktinotherapy", the author summarizes below 4 modern, physical healing methods, of which he gives a clear and concise presentation.

Use of:
1) the concentrated chemical rays from arc lamps or sunlight according to Prof. Finsen's method.
2) X-rays.
3) Ultraviolet rays of the induction spark according to Strebel's method.
4) Becquerel rays.

In his discussion of concentrated chemical rays, the author essentially agrees with the views expressed by Finsen and his students; only, purely theoretically, does — he place greater emphasis on the rays' inflammatory properties than on their bactericidal properties.

The author recommends X-rays especially for Beh, for Hyper-trichosis, Sykosis parasitica and Favus. He finds them contraindicated in all acute, inflammatory dermatoses. —

Strebel's apparatus for utilizing the ultraviolet rays of the induction spark and the Becquerel rays (chemically acting rays emitted from uranium and thorium) is only briefly mentioned by the author. —

GUNNI BUSCK.

Dr. ENGEL (Cairo): Zur Behandlung der Pochen mit rothem Licht nebst einigen Bemerkungen über forcirte Vaccination.

"Therapie der Gegenwart", March 1901.

During an epidemic that occurred in Egypt in the spring of 1900, a total of 177 cases of smallpox were admitted to the Infectious Disease Hospital in Cairo. Of these, 25 were treated according to Finsen's method.

As a result of a well-conducted mass vaccination (in April alone, over 278,000 of Cairo's inhabitants were vaccinated or revaccinated), the epidemic stopped shortly after this measure was put into effect.

The author publishes his results in the above-mentioned thesis, expressing the hope of thereby contributing to spreading knowledge of a method that has not yet gained the attention and dissemination that, in the author's opinion, it deserves.

The author describes the enormous change that occurred in the sickrooms after the exclusion of the chemical rays: the penetrating stench, which the accumulation of many suppurating wounds had made almost unbearable, disappeared completely, and with it the numerous flies that had previously been a constant nuisance for the wounds.

The author has not been able to observe any harmful effect of the stay in the filtered light on the patient or the staff, but he emphasizes that the patient becomes impatient and can only be kept in with difficulty until the vesicles have completely dried up because subjective well-being occurs so early. —

While the skin efflorescence still assumed an abortive, benign character, without suppuration, the author found that Beh. had no influence on the exanthem localized to the mucous membranes (pharynx, larynx, conjunctiva), and he believes that he finds in this the reason for the contradictory results of the various observers with regard to the condition of suppurative fever under Finsen-Beh. It appears from the reported case histories that the affection of the mucous membranes is on the whole of great prognostic significance, something to which previous authors (e.g. Ex. Curschmann) have also drawn attention.

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When writing the — author disregards the four cases of Purpura variolosa and Variola hæmorrhagica, as well as the cases,

Where the mucous membranes are primarily severely affected, the disease will progress like variolois, and the cosmetic result will be satisfactory at that time. Treatment according to Finsen's method.

The author calls this: the first rational and methodical treatment of Variola; he believes that it should be introduced everywhere as an obligatory part of smallpox treatment, and that permanent installations for such treatment should be established in all cities where smallpox occurs constantly or — even regularly.

As can be seen, the author unconditionally and enthusiastically joins the supporters of the method. His view of the influence of the treatment on mortality is all the more strange. The author does not believe that it will lead to any significant decrease in the mortality rate, although he admits that it can have a certain influence on it by preventing mixed infection and complications in the later stages of the disease, something that will be of particular importance for old and weak patients.

One should certainly be careful with numbers, but one can also be so cautious that one's conclusions are misleading. By reviewing the — author's statistics, it also turns out that he has been very cautious!

Koppepttt., of whom the fewest were vaccinated, and none were revaccinated, were interned in 2 pavilions A and B. - The milder cases were admitted to A, the more severe to B, and this distinction between mild and severe cases continued in the same way after the Finsen-Beh. on May 8th was introduced in Pav. B. The mortality rate was before May 8th in Pav. A: — 17 (6 of 35) - in Pav. B: 45 (9 of 20). After May 8th, 20% (1 of 5) died in Pav. A. Of these 5 Ptt., who died in Pav. B also 20% (5 of 25). despite Beh. in red light, one — brought in in the suppuration stage, — was a child who was first and thus came under Beh. too late, since the significance of the method is precisely that it prevents suppuration. The + others had what Forf. just highlights, alongside a confluent skin exanthema, an intensive and severe affection of the mucous membranes of the pharynx and the respiratory tract. —

It is from these figures that the author draws his conclusions!

Note: Various research monographs on Variola have sought to find

statistical data on which days of illness the deaths occur most frequently. It is a given that Finsen-Beh., which only aims at preventing suppuration, cannot influence the mortality in the first 9 days of illness. On the other hand, it is equally clear that the mortality due to cutaneous suppuration and the complications dependent on it will be reduced to zero the moment suppuration is prevented.

It is stated by most authors that Purpura variolosa almost always results in death during the first week of illness. If we disregard these exceptional cases, on the other hand, the greatest mortality occurs during and after the period of suppuration.

Since the author now considers it clinically established that by excluding the inflammatory rays of light from the pox, one spares these from cutaneous suppuration and its consequences, he must logically also conclude that such a treatment must reduce the mortality rate for variola.

The author finally mentions forced vaccination. He believes that it can have a favorable influence on the secondary period, that it hardly involves any danger to the patient, and that it should therefore be tried wherever one does not find it possible to carry out Finsen's method.

GUNNI BUSCK.

DEGRAIS: Des rayons chimiques et de leur emploi dans la thérapeutique des affections cutanées. (Traitement du Lupus par l'appareil Finsen).

Thesis. Paris. 1901.

The author has thoroughly studied the literature that has appeared in recent years on chemical light rays. Magnus Møller and Finsen seem to be his main sources. Without engaging in criticism, he leads the reader in a few pages through the entire physiology of light: the influence of light on metabolism, the erythema of light, pigmentation, excitation and permeability.

After the general part comes a description of phototherapy. Finsen's concentration apparatus for sun and electric light is described in detail. Furthermore, Lortet et Genoud's and Foveau de Courmelles are described.

a Trouvé's apparatus, and an acetylene lamp, indicated by Collevilles. The author speaks with great caution about these last. We still only know the value of the Finsen installation, and the results the author presents are all due to this, as it is found at the Saint Louis Hospital (Dr. Balzer's service). He has a total of 16 case histories: 13 lupus vulgaris partly cured and partly improving. In 3 of the cases Finsen treatment was combined with scarifications (Leredde's suggestion), and the author expresses himself very satisfied with this. The scarifications were carried out under cocaine anesthesia immediately before the light treatment. The remaining 3 were lupus erythematous. They proved refractory.

Finally, the advantages and disadvantages of the Finsen treatment are weighed, and the indications for it are set — all in substantial agreement. out with DAUBOIS's dissertation (which is reviewed in this booklet).

HANS JANSEN.

BAYLE: Contribution to the study of phototherapy. (Method de Finsen).

Thesis. Lyon 1901.

This dissertation was written under the auspices of Prof. Lortet and Dr. Genoud, and the result is that their lamp can replace Finsen's. The work is as a whole very thorough. It is divided into three sections. The first gives an overview of what was known about the effects of light before Finsen, and the French contributions are particularly emphasized; the second is devoted exclusively to Finsen's work, and the third deals with Lortet and Genoud's lamp.

With regard to the last section, reference can be made to the Review of Lortet and Genoud's Original Treatises, as there is nothing significantly new in Bayle.

HANS JANSEN.

FOVEAU DE COURMELLES: La Finsenthérapie. Le Médecin. August 4, 1901.

FOVEAU DE COURMELLES: La photothérapie. — Le Progres medical. November 2, 1901.

The articles mentioned are only a few of the numerous ones that the author has published in the last six months. In all of them, the author moves in the most peculiar way from lyrical outbursts of emotion to deep scientific knowledge and refers to every bit of what has been published in the field of light therapy, without making any distinction whatsoever. However, they all result in the fact that the only excellent thing is an apparatus he himself constructed, which is described and illustrated, but in such a vague way that it has not been possible for the reviewer to get any clear idea of it. The light source can be either an incandescent lamp with special carbon (lampe à incandescense à charbon special), the composition of which has not yet been published", or an ordinary arc lamp. In both cases only 5-8 amps are needed. Finally, it can also be an acetylene lamp. This light source is now placed inside a metal casing, the back of which forms a parabolic mirror, the front a screen with a quartz window in it. The casing consists of double walls everywhere, between which water flows. The light source is placed in the focus of the mirror, whereby all the light is sent forward as parallel rays. There seems to be no concentration. Only the rays that hit the window pass out to Pt. A closer criticism of such a poorly defined lamp is impossible; it should only be emphasized that the use of mirrors was tried long ago in Denmark, but was again abandoned, as they are very quickly attacked and destroyed, at least, when using an arc lamp.

HANS JANSEN.

LORTET & GENOUD: Appareil photothérapique sans condensateur.

Comp. clear des séances de l'Acad des Sciences t. CXXXII p. 527 (March 4, 1901).

LORTET & GENOUD: Phototherapy apparatus without condenser for the application of the Finsen method.

Lyon Medical (March 17, 1901).

Notice sur l'appareil photothérapique de Lortet & Genoud.

Prof. LORTET, Dean of the Medical Faculty at Lyon, who was one of the first to introduce Finsen's Phototherapy in France, has not limited himself to this. In conjunction with Dr. GENOUD, he has sought to produce an improved device for the phototherapeutic use of the arc light, and it is this "lamp" which is presented to the public in these treatises. Although it is hardly as excellent as the authors seem inclined to believe, there is nevertheless a great deal of good in their efforts, and since the lamp has gained quite a wide distribution in France, it has thereby further contributed to paving the way for phototherapy.

LORTET and GENOUD have set themselves the goal 1) to avoid the concentration apparatus, since it absorbs part of the light, and 2) to arrange the lamp for individual treatment, so that every practicing physician can have it in his office. They therefore use an electric projector lamp (an ordinary arc lamp with inclined carbons), which essentially sends the light out to one side, and they place the diseased part a few centimeters from the arc. They make this possible by inserting a metal screen with double walls between the point and the light source, between which cold water flows. This has a circular opening of 2.5 centimeters just in front of the arc, which is closed with a Finsen water-soaked pressure glass. When the point is pressed firmly against this, any heating effect must be excluded. The lamp must be regulated by hand and can be adjusted in all possible ways by numerous screws. It should burn with 12-15 Amp., 55-65 Volt, the arc should be 2-4 Cent.'s distance from the pressure glass and the duration of the sessions should only be 10-15 Min. (in the earliest treatises it is stated respectively 8-10 Amp., 1-2 Cent.'s distance and 15-20 Min.).

Quite apart from the impracticality of having to place the Pt. in that way and having to regulate the lamp by hand, it does not seem reasonable at first that this lamp should be able to provide the same performance as the Finsen installation. It is certainly impossible to find out the relationship between the two devices by calculation. For on the one hand it is not easy to determine how much LORTET gains by the projector position, and on the other hand it is not possible to calculate how much the Finsen loses in the concentration apparatus. We can only point out the following: 1) LORTET does not get

full benefit of the projector position. The crater will then lean somewhat up on the side of the coal, but will not be able to stand absolutely vertical, and the rays will therefore not go straight horizontally out to the side, but a large part at least will go outwards and downwards and thus partly hit the pressure glass at an unfavourable angle, partly not hit it at all. 2) The point is not at all so close to the light source. For in addition to the 2-4 cents. that lie between the arc and pressure glass, this represents a further 2 cents., so that the treatment distance becomes 4-6 cents. As the treatment distance of the lens, one must set the distance from the arc to the front lens in the concentration apparatus; here the rays are made parallel and thus retain their intensity as far as possible in the further course. This distance is 12 cents for a usual 7 cent. apparatus. LORTET therefore takes the light to a place where it is 4-9 times stronger than where Finsen takes it. But whether this small advantage in connection with the projector position could compensate for: firstly Finsen's concentration, whereby the light is amplified by about 30 times according to the calculation, furthermore his 5 times as much power consumption and finally his 4-5 times as long processing time, it is unlikely.

The question can, however, only be resolved by exact comparative experiments. Of such LORTET and GENOUD do not cite a single one. They conclude exclusively from "les effets réactionnels et curatifs". Exanthem and bulla formation occur just as with the Finsen treatment. But it is probably not known to Forff. that Finsenapp. can do quite the same in an even shorter time. The maximum reaction is reached quite quickly, often in just a couple of minutes, and an increase in the time of illumination or the intensity of light does not significantly change its appearance, whereas it must be assumed that the depth effect becomes all the greater. Finsen has therefore rightly never been satisfied with the time and intensity of light that were just necessary to obtain the maximum reaction, but has gone much further and can probably precisely for that reason achieve a greater depth effect.

It should be added that here at the Light Institute we have carried out a series of experiments with the LORTET lamp, which will be published later, and the main result of which has been that this lamp is 3-4 times more effective in terms of bactericidality and depth of effect.

weaker than a Finsen installation with a 70 Amp. arc lamp and a 7 Cent. concentration lamp, and thus represents a significant step backwards.

HANS JANSEN.

STREBEL: SOME LIGHT THERAPEUTIC QUESTION. Vienna clinic. Roundtable No. 50-51, 1900.

STREBEL: EIN BEITRAG ZUR FRAGE DES LICHTTHERAPEUTISCHEN INSTRUMENTARIUMS. Verh. der deutshen dermatol. Gesellschaft. Breslau 1901.

STREBEL: DIE BRAUCHBARKEIT DES INDUCTIONSFUNKENLICHTES IN DER THERAPIE. Vortrag. Die 73. Versammlung deutsche Naturf. und Arzte. Hamburg 1901.

Dr. STREBEL in Munich has in recent years been very enthusiastic about phototherapy, especially its physical side, and shows considerable expertise in this area, also reviewing much criticism, although it seems to the reviewer that he is somewhat too inclined to put forward hypotheses that are not entirely justified.

In the first treatise the author rightly takes a strong distance from the so widespread light boxes, whether they are equipped with arc lamps or only with incandescent lamps. They only do very little in terms of photochemistry, and harmful gases accumulate in them. Instead he suggests leaving the Pt. in the light of strong projector arc lamps with mirror reflectors. He considers it pointless to shoot colored glass plates. Since the author here at all goes to the field against the much charlatanism that is carried on with the use of different colored light, he touches on the treatment of smallpox and here shows a strange lack of understanding, saying that he cannot see why it should be red light; darkness would have to do the same.

In the second, the author deals with the important and modern question of the value of ultraviolet rays. He demonstrates their great absorbability by a series of experiments; thus he finds that a horn plate of 1 mm. cuts off the greatest part of them like glass. Possibly, however, they could in concentrated form

penetrate better, and he tries this by collecting the ultraviolet rays differentiated by a prism with a quartz lens, directing the cone of light towards a piece of skin and holding a fluorescent screen behind it; while nothing was seen through a compressed rabbit ear, on the other hand, recognizable fluorescence came through freshly removed human skin. Apart from this experiment, which one could probably have wished to repeat and vary, the moral is that the external ultraviolet rays are of little value when it comes to penetrating something into the skin. In the conclusion, the author proposes to replace the lens concentration with mirrors. A new mirror metal has been developed, called Magnalia, which is supposed to be resistant to the ozone effect of the arc light. With some drawings he shows how he imagines the installation in such a case. In the same lecture, but without connection with the rest, the author presents his "Funkenlicht", which is the main subject of —

the 3rd treatise. The principle of this "STREBEL" lamp is to let strong induction sparks pass between electrodes of aluminum, cadmium or zinc. This creates a light that is very rich in ultraviolet rays, while there are only a few luminous ones. It is almost quite cold, so that it can be introduced into the body cavities, and it is here that the author will seek an area for "ultraviolet therapy", as he suggests that the mucous membranes are better permeable than the skin. Finally, he presents some therapeutic results obtained with this light, including 2 cases of gonorrhoea and 2 cases of urethritis in men.

HANS JANSEN.

At Gyldendalske Boghandels Forlag, previously came out:

ABOUT USE IN MEDICINE

OF

CONCENTRATED CHEMICAL LIGHT BEAMS

BY

NIELS R. FINSEN.

Price: 1 Kr.

Georges Carré et C. Naud, Éditeurs, Paris, has published:

LA PHOTOTHERAPY

PAIR N.

R. FINSEN.

I. LES RAYONS CHIMIQUES ET LA VARIOLE.

P. LA LUMIÈRE COMME AGENT D'EXCITABILITY. DU LUPUS — III. TREATMENT

VULGAIRE PAR LES RAYONS CHIMIQUES CONCENTRÉS.

F. C. W. Vogel's Publishing House, Leipzig, has published:

Über die Anwendung
von concentrated chemical light rays in medicine

by

Niels R. Finsen.

1899. Price: Mark 1:20.

(Translation from Danish).

Über die Meaning der
chemischen Strahlen des Lichten für Medicine
und Biology.

Drei Abhandlungen.

By

Niels R. Finsen.

1899. (Translation from French of "la Photothérapie").

CONTENT.

I. On the Use in Medicine of Concentrated Chemical Light Rays. By N. R. FINSEN, (With 8 Pictures and Figures).

II. On the Absorption of Ultraviolet Rays by Blue Liquids. By VALDEMAR BIE.

III. Studies on the Effect of Light on Smallpox Vaccines. By N. R. FINSEN and G. DREYER.

IV. On the Production of Arc Light by the Aid of Cooled Electrodes. By S. BANG.

V. On the Effects of Light on Microbes. By S. BANG. (With 6 Figures).

VI. Treatment of Smallpox by Exclusion of the Chemical Rays of Daylight. By N. R. FINSEN.

VII. Treatment of the Rose with the Exclusion of the Chemical Rays of Daylight. By N. R. FINSEN.

VIII. Literature review.